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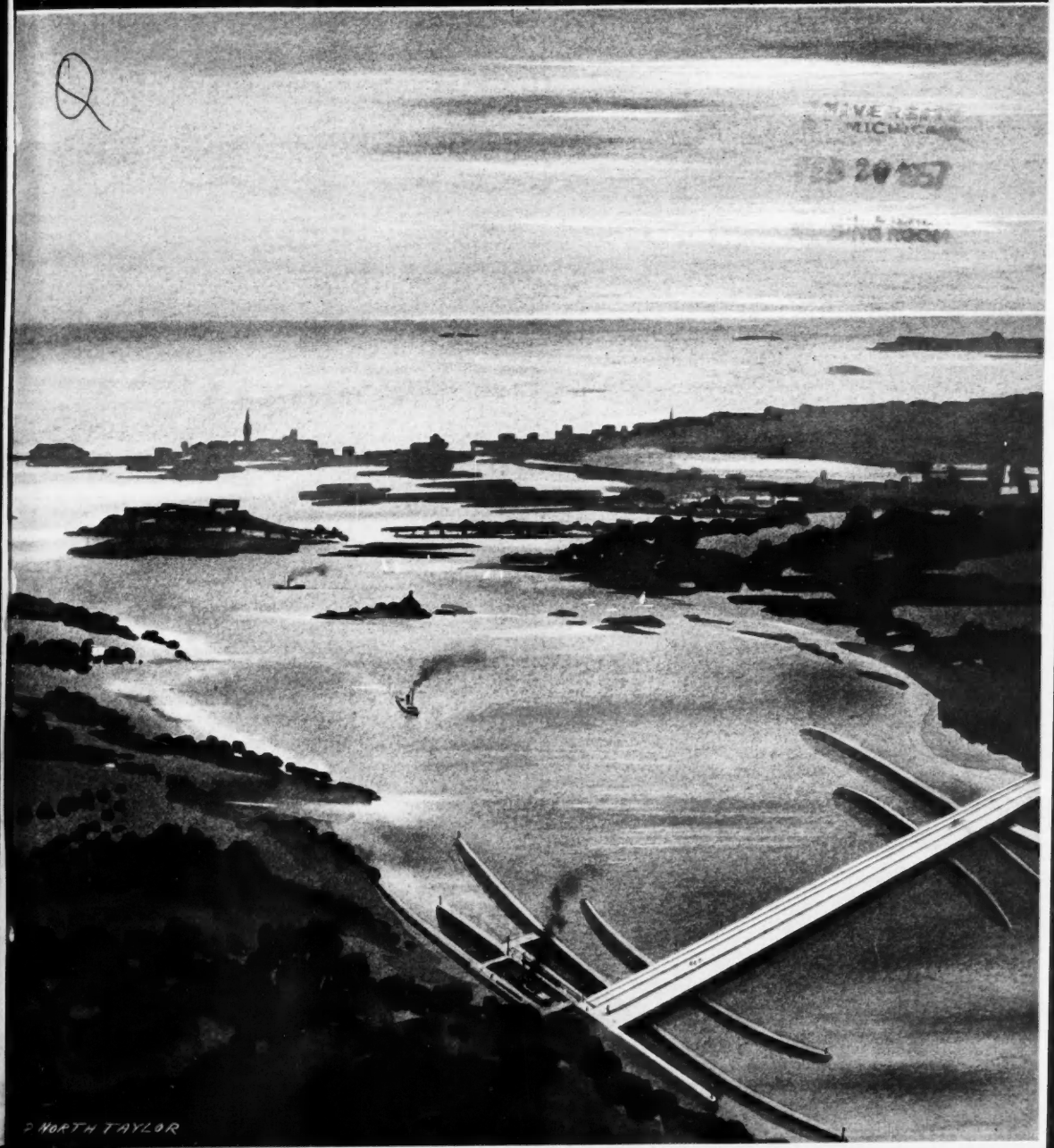

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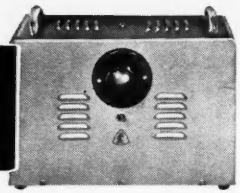

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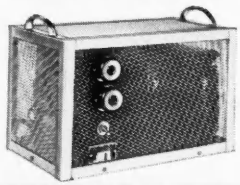

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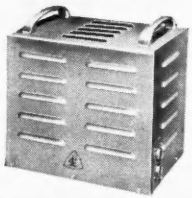

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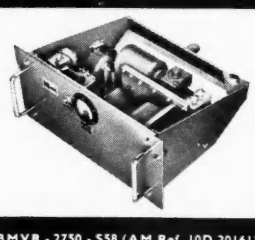

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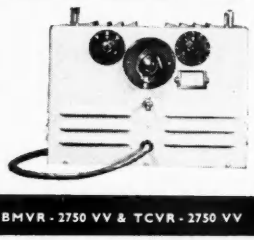

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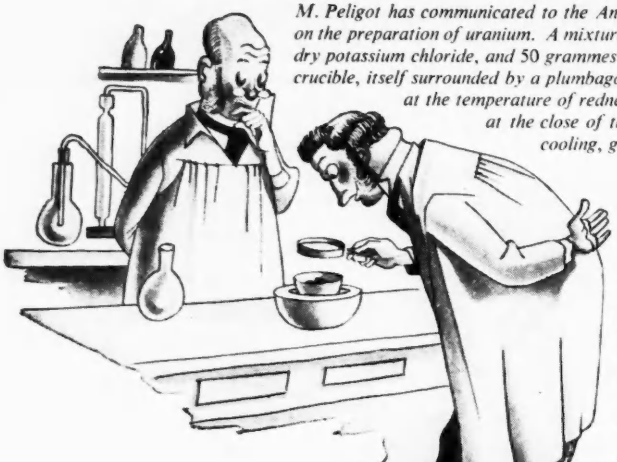
COVER PICTURE: An artist's impression of the tidal barrage scheme under construction at St Malo in France. A detailed article on this project appears on p. 51.

M. Peligot finds uranium



M. Peligot has communicated to the Annales de Chimie et Physique (xvii, 363) a short note on the preparation of uranium. A mixture of 75 grammes of uranous chloride, 150 grammes of dry potassium chloride, and 50 grammes of sodium in fragments is introduced into a porcelain crucible, itself surrounded by a plumbago crucible. The reaction is effected in a wind furnace at the temperature of redness; but the heat must be increased for a short time at the close of the operation. In the black slag may be found, after cooling, globules of fused uranium.

The new method of producing uranium was announced in the first issue of Nature in 1869. Monsieur Peligot, who twenty-eight years before had first isolated the metal, discovered by Klaproth in 1789, was opening the door a little more widely to the possibility of an Atomic Age a century later.

In recent years the priority attaching to the atomic energy programme has restricted their availability, but uranium compounds are now again available and figure among the several thousand fine chemicals of very high purity supplied by B.D.H. for science and industry.

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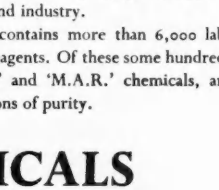

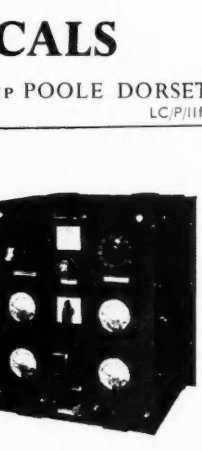

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THE PROGRESS OF SCIENCE

THE NEW CHAIR-BORNE SCIENTISTS

In general—except for mathematicians and the theoretical physicists—science is not a "chair-borne" occupation. It depends on experimental results and observations. Yet there has arisen a new important role for scientists as desk-working or occasionally peripatetic planners. This new kind of job is sadly underrated by many laboratory workers.

Until a century or so ago, anyone of intelligence willing to make careful and accurate observations could contribute to this systematised corpus of knowledge without much reference to earlier or contemporary workers. In fact, with little training any man could be a scientist. He could more or less scratch anywhere at the boundaries of knowledge and hope to find, if not pure gold, at least some useful ore. But as the scale of scientific effort has grown, the structure of science has become more complex, the training more necessary, the body of knowledge incomparably greater, and the social character more marked. Today it would be foolish for anyone to approach a problem without a preliminary survey of the literature. With varying degrees of efficiency vast organisations of abstracting or scientific documentation services have correspondingly been set up to meet this need.

But with this has also come a development of planning. What kind of scientific work can be planned? In the first place, those fields where the scope of at least a primary investigation can be clearly seen. For example, a chemical structure may be checked by synthesising the limited number of possibilities; attempts can be made to produce "tailor-made" substances by introducing a number of trial chemical groups into complex compounds; biological assays may be made of the potency of drugs, hormones, or other materials; the scope of a translation machine can be widened; a geological survey may be carried out. The big increase in the size of physical apparatus and of the teams needed to tend them makes planning imperative; moreover, contact must be maintained between the planners themselves and the bench workers, particularly when the two become physically separated.

No formal training is yet available for the science planner. Yet the Ministry of Supply estimates that it will spend £192 million on research and development in 1956–7—probably three-quarters of the national expenditure on science—and lists £3 million of this as allotted for headquarters. This will naturally include pure administrators, accountants, and their staffs, but the tables in the Estimates show a number of high-ranking scientific controllers, each with an extensive scientific staff. On a smaller budget DSIR, with an estimated expenditure of £10 million for the same period, will spend a higher proportion, at £250,000, on their headquarters staff.

If attempts were made on the national scale to direct attention in science to where it could most clearly advance human welfare the importance of this type of work would grow. "What we need to evolve," suggests Bernal in his recent "Science in History", "is an organisation which makes use of the greatest advantages that can be drawn from co-operative action, while preserving the advantages that belonged to the older period of unorganised science. It must combine the character, flexibility and individual initiative of the science of the past, with the team work and strategy needed to cope with the vaster problems of the future."

Perhaps if we had this, science planning would become "recognised". Meanwhile, this note may well be taken as a skittle put up to taunt scientific marksmen. To the men responsible for planning scientific attack in individual large organisations the case does not need arguing. They have set up forms of organisation which satisfy the demand because they appreciate the need for this new kind of scientific effort.

But do laboratory scientists? We draw attention again to the article by E. S. Hiscocks in the September issue of DISCOVERY, p. 367, on "Research Administration".

NUCLEAR POWER AND NUCLEAR PHYSICS

The tempo of the development of civil nuclear power grows faster, the construction targets of earlier plans fall below the minimum achievement anticipated in the current programme, and, most gratifying, the performance of some of the reactors promises to exceed expectation.

The remarkable progress made during the last year is described in the second annual report of the United Kingdom Atomic Energy Authority, together with a brief outline of their future programme (H.M.S.O., July 1956, price 2*s.* 6*d.*). Perhaps the greatest importance belongs to the reactor programme. The Calder Hall reactors, and three further units that are being constructed to expand the production of military plutonium, have been designed for optimum plutonium production. Tenders for the construction of the first primarily power-producing units have now been awarded by the Central Electricity Authority. Although these reactors will necessarily be based on the designs of the Calder Hall reactors, a considerably improved power output per unit weight of uranium is confidently expected.

Such gas-cooled reactors, using natural or only very slightly enriched uranium, are, at present, the most economical way of increasing our supplies of fissile material and at the same time generating considerable amounts of useful power. In this country, and probably in a number of other countries, they represent the first phase in the logical and economical development of a large-scale nuclear power programme. The rapid and successful development of these reactors tends, perhaps, to obscure the more important studies which are being made and which will determine the next phase of the industrial development. A number of these investigations are being carried out by means of "loops" in which an element of a proposed reactor is tested under operating conditions by insertion in an existing reactor. A particularly valuable loop has been constructed in the Canadian NRX reactor for this purpose and provides

opportunities for operation in a high neutron flux. Pressurised water and sodium-cooled graphite moderated reactors are the principal types that are being considered for the second phase of development when more highly enriched fuel elements can be used.

Our limited manpower and economic resources force us to be more sparing in embarking on large-scale experiments. The Authority at present only operates four complete research reactors: the graphite moderated reactors GLEEP and BEPO and the fast reactors ZEPHYR and ZEUS. Two more elaborate, heavy-water, moderated units, DIDO and the very high-flux PLUTO, are being constructed, and a "swimming pool" type reactor, LIDO, primarily intended for shielding studies, is now complete. Outside the Authority, the Associated Electrical Industries are constructing a research reactor at their Aldermaston laboratories. But it is surprising, particularly in view of our acknowledged deficiency in technical personnel, that there are, as yet, no indications that any other research institutions, including particularly the universities, propose to install a reactor, although there is every indication of cordial assistance by the Authority in such a project.

At present the most important large-scale experimental reactor being constructed by the Authority is making progress. The performance of the sodium-potassium alloy-cooled fast-breeder reactor at Dounreay in Scotland may well determine the direction of progress in the third stage of industrial development.

The Commonwealth appears to be well provided with raw materials; the production of uranium from the South African gold-bearing reefs is still growing. The dominant factor is now the cost of exploitation of newly discovered deposits, and adequate supplies of reasonable high-grade concentrates seem to be becoming available at a cost of about 71*s.* per pound of uranium contained.

The report contains only two disappointments. The New Zealand heavy-water production project has had to be abandoned because the product could not compete economically with the American or Norwegian product. Perhaps more disturbing is the pessimistic tone of the report in relation to the export possibilities in the next few years. It is not recognised that the export pattern that is established during this period might persist for a number of decades; the construction, and possibly subsidising, of research reactors may naturally lead to the ordering of power-producing units.

The report finds room to mention a proposed accelerator for the production of 6–7 G.e.v. protons, but nuclear physics is now rather the hobby than the business of the Authority and the vanguard of progress in nuclear physics has a very tenuous connexion with nuclear power. However, the two subjects have one property in common: the high cost of experimental facilities. For this reason the last few years have seen the inception of novel development in international co-operation, the Conseil Européen pour la Recherche Nucléaire (CERN). The convention agreeing to the establishment of this organisation came into operation in September 1954, and the twelve member States have now all deposited their signed instruments of ratification. The purpose of the organisation is collaboration in fundamental research in nuclear physics. An establishment has been created just outside Geneva, where two high-energy accelerators, a synchrocyclotron and proton synchrotron, will be installed. The first annual report from CERN has recently appeared. The 600 M.e.v. synchrocyclotron is making rapid progress and should be completed next year. The much more ambitious 25 G.e.v. proton synchrotron will not be complete until, perhaps, 1960. Preparation of all the auxiliary facilities to enable these machines to be used to the greatest advantage is steadily taking place. The most noteworthy feature of the report is the evidence of smooth and efficient working in a new international venture that may well become a pattern for co-operative research projects in especially costly fields.

WEIL'S DISEASE: A WARNING

Reports of death from Weil's disease, such as appear from time to time in the Press, are often unnecessarily alarming. It is a grave disease, but not always fatal. It is as well to reject out of hand such rumours or reports as that (*a*) Weil's Disease is invariably fatal; (*b*) it kills within seven days; and (*c*) there is no known cure.

The causal organism is a bacterium, *Leptospira icterohaemorrhagiae*, which is widely prevalent in the kidneys of rats, and is discharged in the urine. It is from this source that, directly or indirectly, man becomes infected. The disease first attracted attention in its stage of infective jaundice and bore the names *Spirochaetosis ictero-haemorrhagica* and *Leptospirosis* or, more briefly, Spirochaetal or Leptospiral jaundice. Later it became clear that in something like 60% of the total cases observed, jaundice did not develop. This fact accounted for a reversion to the earlier non-descriptive title of "Weil's Disease", as the synonyms suggestive of jaundice were not appropriate in the majority of cases.

The onset of symptoms may be gradual or sudden, the principal features being severe headache, general weakness with acute muscular pains, shivering and high fever, nausea and vomiting. Conjunctivitis has a certain suggestive value in the diagnosis. This phase lasts approximately one week, during which time septicaemia occurs, antibodies are not detected in the blood, and leptospires are not found in the urine. During this stage there is little to indicate that diagnosis of influenza is incorrect, unless note is taken of the nature of the risks to which the patient has been exposed.

In the second stage there is absence of leptospires and development of antibodies in the bloodstream and discharge of leptospires in the urine. If jaundice has not appeared by the end of the second week, the attack may be regarded as mild, and the symptoms may rapidly abate. In rather more severe cases where the outcome may be favourable, the fever falls and general condition improves, but jaundice may continue for about a fortnight. In less satisfactory cases, the jaundice becomes intense, discharge of urine becomes increasingly difficult, solid bodies in the kidney discharge become pronounced.

Nose and generalised bleeding, blisters and blotches of the skin are common, while falling blood-pressure

and rising pulse are indicative of the gravity of the case. Renal failure is accompanied by kidney damage, and restoration of the kidney function is all-important.

In the third stage, convalescence is accompanied by the development of antibodies in the blood and by the excretion of organisms in the urine. According to the severity of the illness, the period of convalescence may be, and often is, greatly prolonged. In many cases there is a second rise in temperature during the third week of the illness.

Recent figures for the British Isles, based on analysis of approximately 900 cases, disclose an overall mortality rate of 16%, the age range being from 3% of those under 15 to 33% of those over 60. Several investigators find that in the majority of fatal cases death occurs after and not before the tenth day of illness.

Special surveys of workers in certain vulnerable occupations have established that many persons have at some time in their lives been subject to mild attacks of the disease which were unrevealed by diagnosis.

None can say where Weil's Disease will break out next among human beings, but there can be general agreement that the conditions conducive to attacks by this dread disease are present in many areas and locations in the country. Only rats are responsible for the spread and maintenance of the disease. If there were no rats, there would be no Weil's Disease. It has been found by sample surveys on low-lying land where there is standing water or sluggish streams and inadequate disposal of foul matter, that, among the rat population, there is a high incidence of infection by the germ of Weil's Disease. The fact that in some of these areas there has been no reported case of human infection is quite fortuitous and is no guarantee against outbreaks.

Among workers in wet mines, and among sewermen, fish "gutters", filleters and cleaners, and land-workers in proximity to stagnant water, Weil's Disease is to be regarded as an occupational hazard, while bathing or accidental immersion in fouled water may also be dangerous. Infection is through abrasions or punctures of the skin or through the mucous membrane. It is considered also that these minute organisms are capable of penetrating the unbroken and healthy skin of a human being, and this possibility should not be ignored.

Cases of compensation claims through the Courts are not uncommon, and labour unrest in certain occupations has led to actual or threatened suspension of work until the conditions have been improved.

There is strong ground for pressing for more systematic biological testing of the rats in all doubtful locations in order to get a real picture of the extent to which the rat population is infected. It is claimed that the result would shake any equanimity with things as they are.

The Local Authorities have the requisite powers enabling them to require that owners and occupiers of land should get rid of rats on their premises, and there are commercial servicing companies skilled in rat extermination. The Ministry of Agriculture and Fisheries is given responsibility for seeing that the statutory functions are discharged.

HOW CRATERS ARE FORMED

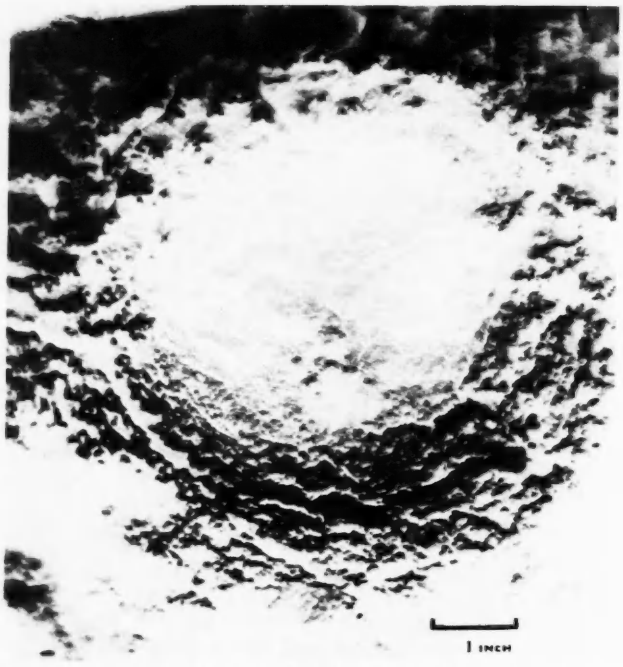
It is only in recent years that the study of craters has been seriously considered from a quantitative point of view, and craters on the surface of the Moon have for a very long time attracted discussion and have defied satisfactory explanation.[1-2] With regard to lunar surface features, two main schools of thought have existed on this subject. It has been suggested that they may result from "magmatic upheavals" in the Moon's subsurface regions, and many attempts have been made to describe mechanisms by which craters could be formed from such occurrences. Current publications on the subject, however, appear, on the whole, to favour the view that lunar craters and valleys are the marks of meteoric impact and grazing collision. Dr H. C. Urey is a strong advocate of the latter idea, having dismissed, on considerations of the Moon's heat balance, the possibility of the existence of a molten subsurface region on the Moon.[3] It is therefore in keeping with the scientific principle—proceeding from hypothesis to experiment—that recently the artificial creation of impact craters has been studied on laboratory models. Gilbert Fielder, of the University of Manchester, has carried out a study of several aspects of craters produced in plaster-of-Paris powder, and it was on his suggestion that F. N. Johnson undertook an extension of this work.

The method of crater production was one that had been adopted by earlier investigators in the same field—notably Ley[4] and Wegener[5]—and consisted of releasing powder missiles from slightly conical cylinders on to a depth of the same substance. Craters so produced usually had diameters ranging from three to twelve centimetres, and possessed ring-walls and central mountains similar to the ones shown in the photograph.

Two lines of research were followed: qualitative and quantitative, the former course leading to several interesting conclusions, particularly concerning the internal structure of impact craters, and the origins of the "ray" systems. The study of the structure of craters was facilitated by the use of stratified base powder, for it was then merely necessary to solidify the plaster immediately after the impact and to cut it into sections.

Arching of the strata occurred under the ring-walls, and, to a much smaller extent, immediately below the central mountain. The latter observation is most interesting, as Dr G. P. Kuiper[6] has recently stated that he considers the existence of a central mountain in an impact crater to be caused by the remains of the original missile and not to be due to a "rebound" of the material in the receiving surface. From experimental results, however, it would appear that a central elevation is, in fact, a manifestation of the internal structure of the craters, although missile material does, it is true, add appreciably to its size.

In the course of the missile's impact with the base powder, great quantities of material were ejected in the form of streaks extending, for the most part radially, up to six or seven metres from the centre of the crater. Such rays seemed to be composed almost entirely of missile material, but there existed shorter rays, originating from



Photograph of crater produced in white powder. Oblique lighting. Note the central mountain and the "terracing" of the ring-walls.

the ring-wall and at times tangential to the crater perimeter, which were made up of powder from the lower strata of that region.

Not all the ejected material went to produce rays, however, and some of it, acting like a shower of smaller, secondary missiles, produced lines of craterlets at distances of twenty or thirty centimetres from the primary. These distances seem to indicate that the secondary missiles must have been thrown at fairly high angles to the horizontal. The lines which the craterlets formed in the surrounding base powder were of two distinct kinds; they were either radial to the parent formation, or formed curves, having their centres inside, or near to, the main crater.

In pursuing a quantitative course of study, the object was to correlate, if possible, different measurements taken from the craters both with each other and with characteristics of their productive missiles. Fielder, having already touched on this subject, had found that the volumes of the impact craters were proportional to the square roots of the energies of their respective missiles. This was verified and other such relationships formulated. Crater volumes, it was discovered, also had a definite linear connexion with momenta of the missiles, as did craterial diameters and depths. The constants of proportionality were found in all cases, being characteristic of the medium used for the experiments—in this case plaster-of-Paris powder, but in earlier work, cement powder.

In 1949, Dr R. B. Baldwin[7] reported the existence of a relationship between the depths and diameters of many different kinds of craters, from the largest of the lunar craters down to explosion pits a few feet in diameter. This relation he gave in the form of a logarithmic quadratic,[7] but the powder impact craters yielded a very simple linear equation of the form: $d=4{\cdot}65s-1{\cdot}75$, where "d" represents the diameter and "s" the depth of an impact crater. Of course, the extremely restricted range of measurements that it was possible to take from these formations may hide any tendency for the connexion to become other than linear.

The solution of the whole question lies in the comparison of lunar and terrestrial or man-made formations, which is what Baldwin has tried to do. The serious study of craters has little more than begun, however, and there is much to be done and more to be learned in this interesting new field.

A fuller treatment of the quantitative results indicated above, together with certain results in tabular form, is shortly to appear in the *Journal of the British Astronomical Association*.

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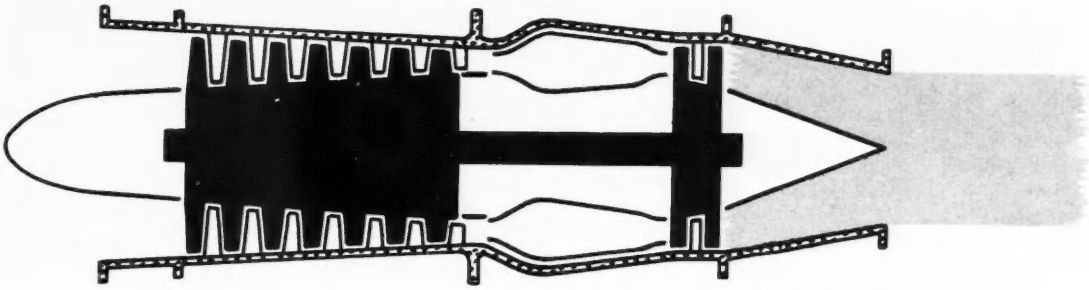
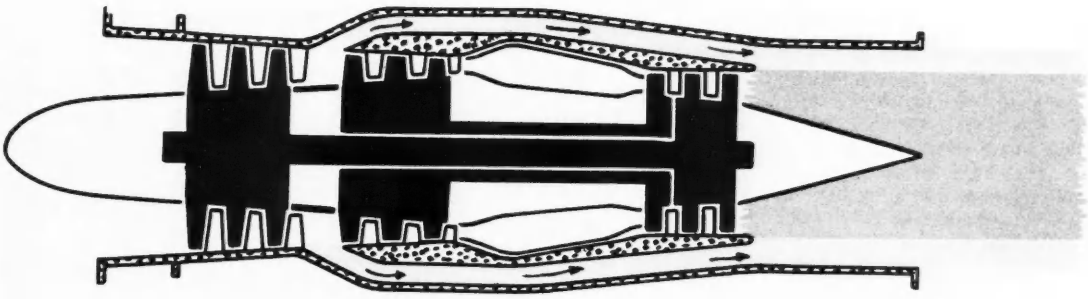
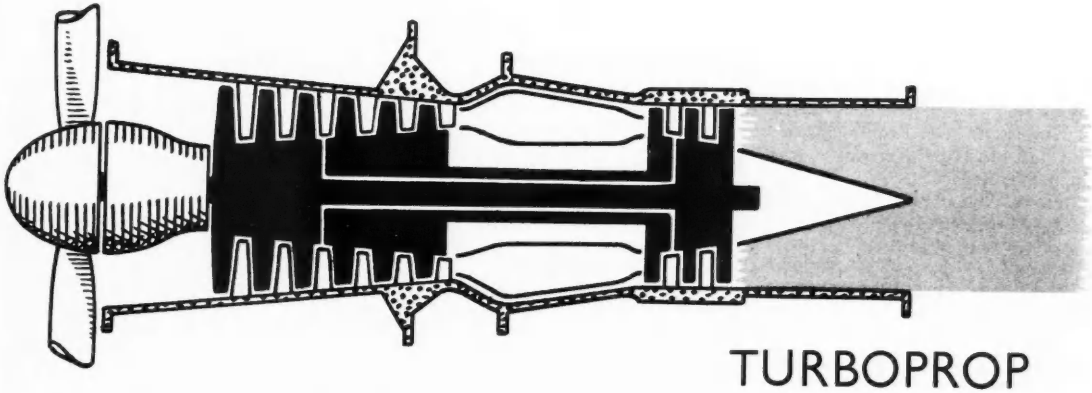


TURBOJET



BY-PASS



TURBOPROP

The top drawing shows the conventional, axial-flow type turbojet engine, through which air makes a virtually "straight through" passage. The compressor, in this case of seven stages, is installed at the front of the engine; the turbine, mounted on the same shaft, is at rear. The exhaust gases are ejected in a single mass at the rear. The by-pass is illustrated in the second drawing. This is a "twin-spool" engine which consists of a low-pressure compressor and turbine and high-pressure compressor and high-pressure turbine. The low-pressure compressor, which is driven by the low-pressure turbine, feeds part of its air to the high-pressure compressor, and the rest is ducted around the engine. The high-pressure compression air passes first through the combustion chamber and high-pressure turbine, and then through the low-pressure turbine. The by-passed air combines with the hot jet gases on ejection to slow and cool them. The turboprop is shown in the third drawing and in this type of engine the greater part of the energy is used to drive a propeller instead of being expelled in the form of jet thrust. This particular type of turboprop is also of the twin-spool type, the compressor being driven by a turbine separate from the propeller's.

The Boeing 707, which will soon be fitted with the Conway engine. (*A Boeing Airplane Company photograph.*)

THE BY-PASS AERO-ENGINE

One of the problems airlines have always had to contend with is the efficiency of their aircraft compared with those of other airlines. To capture a large share of the air traffic they have always needed the best aircraft, which, inevitably, are always the newest. The demand for new aircraft has increased enormously in the last few years because of expanding traffic, and there are now well over 400 major airliners on order—some of which have yet to fly as prototypes.

Apart from incorporating all the latest navigational aids, these airliners will have the latest engines. Many will be turbojets and many will be turboprops, but there is another form of engine which will power these airliners and which is particularly interesting. This engine is the by-pass, which has first been produced by Rolls-Royce Ltd in the form of the Conway.

While resembling an ordinary turbojet in outward appearance, the Conway embodies a number of features which make it a unique form of power.

Basically, the by-pass is a gas turbine engine which works in a similar manner to the turbojet, but instead of the air that is taken in going directly through the engine, part of it is "by-passed" or diverted past the main part of the engine to flow through a channel surrounding it. The result is that the whole of the combustion area of the engine is enveloped in a blanket of relatively cool air.

In the ordinary turbojet engine, the air is taken in through an intake, put through a compressor, and then sprayed with fuel. The combined fuel-air mixture is ignited, and the energy created by the combustion is used to drive a turbine. The turbine, in turn, expels a great force of air rearward, which has an equal reaction in thrusting the engine forward. This is the essence of jet propulsion.

In the case of the turboprop, instead of the greater part of the energy being expended in the form of jet thrust, it is converted into mechanical energy to drive a shaft, upon which is mounted a propeller.

The efficiency of the turbojet is largely governed by the extent to which the air taken in can be heated, because temperature is a very important factor in operation. The higher the combustion temperature in shaft power gas turbines the better, because this increases both the specific power and the power plant efficiency. There is, however, an optimum point to which the temperature can be raised, as after a certain temperature is reached, the velocity of the exhaust gases becomes excessively high, and there is a falling off in propulsive efficiency. A means is needed of slowing the exhaust gases to a velocity at which propulsive efficiency is quite high. This is where the by-pass scores. Air that is ducted around the combustion chambers is made to combine with the main stream of the efflux, and in so doing it slows the exhaust gases and cools them. The result is an engine providing similar thrust to a turbojet, but running more economically and at a quite high combustion temperature.

In addition to the improved efficiency of operation, the by-pass is lighter than the turbojet: its high-pressure compressor is smaller because it has less air to handle. In the Conway, 60% of the air taken in goes through the main part of the engine, and 40% of it is ducted to the annular by-pass. It has been shown that, for the same airflow, the ordinary jet engine is 24% heavier on direct engine weight and 30% heavier on installed weight. A jet engine giving only 7½% more thrust will, in other words, be 30% heavier than its by-pass counterpart. With two engines scaled to give the same thrust, the jet engine would be 21% heavier than the by-pass. This difference in weight is of particular interest to airline operators, because a lighter engine means that more payload can be carried, or else more fuel, which means a greater range.

Another advantage of the by-pass is that it is a quieter engine than the turbojet because the velocity of the exhaust gases is less. It has been found that the noise varies with the speed of the jet gases, and the Conway has been found to be appreciably quieter than a Rolls-Royce Avon turbojet tested under the same conditions.

Additionally, the by-pass is considered to be a "safer" engine than the conventional turbojet, because the blanket of cool air that surrounds the combustion chambers reduces the fire hazard in the event of a crash.

At present, the Conway is still in the development stage, but Rolls-Royce are pressing ahead with trials, and are now concentrating on producing a new "family" of Conways capable of almost twice the power of the first engine.

Experts have shown confidence in the engine by planning for its installation in the American jet airliners now under construction. Four airlines, namely Trans-Canada Air Lines, Lufhansa, Air India International, and BOAC, have now asked for Conway engines for the Boeing 707 and Douglas DC-8s they have on order. Originally, both these airliners were to be powered by American turbojet engines; but the Conway was proposed as an alternative power plant, and Trans-Canada Air Lines were the first to accept it. The Conway develops 13,000 lb. thrust at the present time, compared with 10,000 lb. of the American Pratt & Whitney JT-3. By the time the American airliners are ready for service, even more powerful versions of the Conway will undoubtedly be available.

The Boeing 707, a big, swept-wing airliner, already has over 500 hours of development flying behind it, but

the DC-8 has yet to be built. Both aircraft are scheduled for service in 1960. The engines of these airliners are mounted in pods under the wings, which contrasts with the usual British method of installing the engines in the wing roots. Both methods of mounting have their advantages, but in the case of the Conway it appears that the "podded" method is the better, as this permits an uninterrupted flow of air around the engine.

The combination of the by-pass and the large American airliner is one which will soon become known and accepted throughout the world. It is very heartening that British engines hold such a high place in aviation, and even more heartening that they are relied on to power American aeroplanes.

ATOMIC ENERGY IN AGRICULTURE

News of the foundation of a research institute devoted exclusively to the applications of atomic energy in agriculture was given recently by Mr Mansholt, Minister of Agriculture in the Netherlands. He was speaking at a meeting held at Wageningen, Holland, and convened by FAO, as the initial activity of its European Contact Group on the Uses of Isotopes and Radiation in Agricultural Research.

The subject matter was taken under five main headings: uses of isotopes in soils research; plant science; animal science; use of radiations in plant breeding; and food preservation. A good deal of the work in Europe has been on problems discussed at the 1955 Geneva meeting by workers in U.S.A. and U.S.S.R. (both of which were represented at Wageningen by observers). There has been the Netherlands work on photosynthesis, and that in Sweden on the inter-connexions between forest-tree roots. An outstandingly interesting session dealt with plant breeding. At this, Prof. Gustaffson (Sweden) told delegates that a radiation-induced field pea is now on the market in his country, as well as the field mustard, which appeared some time ago. He said that on a five- to six-year average new barley varieties from radiation-induced mutants had a yield at least as high as the highest types normally produced. They have much stiffer straw, better suited for mechanical harvesting, and allowing higher fertilisation rates. Prof. Gustaffson referred also to the great economy in time and labour effected by the use of x-ray photography to replace orthodox methods of seed-testing—a means of doing in minutes work that previously took weeks. Last year at Geneva, Gustaffson had been among those most frankly sceptical of the Russian work on growth stimulation by irradiation. Now he admitted the "distinct possibility" that there might be some stimulation of growth. Besides having himself got results which might lead him to change his mind, he had been much impressed on a recent visit to Russia by work of Temefeef-Ressovsky, which he considered much more reliable than that put forward by the Russians at Geneva.

The use of radiations in food preservation was very fully discussed under the chairmanship of Prof. Kuprianoff of the Karlsruhe Federal Research Institute of Food Preservation, and with a notable contribution from Dr J. C. Boursnell of the Unit of Reproductive Physiology at Cambridge. It is evident that European governments are united in approaching this subject very cautiously, far more so, for example, than the United States. Progress will be slow in Europe, not only because of doubts as to the risks involved in encouraging the marketing of irradiated foodstuffs, but also because of the large technical resources needed for this work. In this connexion Dr Seligman said that it would soon be possible to start large-scale feeding trials on rats at the new Wantage research station. The results of such tests will be of obvious value to all countries working in this field. In general, low dosage rates of radiation are preferred, and their use is favoured in combination with such normal methods as refrigeration. Irradiation is seen as a useful way of dealing with insect pests in packaged foods (there are more difficult problems where bulk food-stores are being considered), and this might be of especial value in tropical countries.

The delegates also had general discussions on such subjects as training facilities, waste disposal, and safety measures. A full directory of research institutes working in the field is understood to be in hand at FAO, and this will contain information on training facilities where these are available. When laboratory hygiene came to be discussed, it appeared that Britain has a considerable lead, not only in Europe but also over the U.S.A. American workers do not appear to have made such detailed studies of the protection of the individual worker using radioactive "tools" as those in this country, some account of which was given by Dr Boursnell. (This will shortly be appearing as an official publication.) Another field of competition would seem to be in the provision of "packaged" radiation sources, which Dr Seligman mentioned in describing British facilities. Referring to American progress in their production, he said that he hoped Britain would, by 1960, be able to supply such sources at a price competitive with those expected from the U.S.A.

If a single conclusion is to be drawn from this meeting, it is that the European governments are well aware of the importance to agriculture of these new research tools, although they appreciate, too, that they are not themselves an answer to problems: rather they can be seen as essential additions to the equipment of the agricultural scientists. Aware of their limited resources in materials, laboratory facilities and manpower, they see clearly the need for international co-operation and for pooling resources wherever possible, while still feeling free to pursue lines of research most profitable to each country.

It may be said that Britain has allowed the Netherlands to take the lead at the international level, at least where agriculture itself is concerned, since the new institute at Wageningen is deliberately intended to be an international centre for work in this field. However, it was clear at the meeting that in many other subjects —amongst them certain aspects of food preservation and protection for the laboratory worker—we have a considerable lead in Europe.

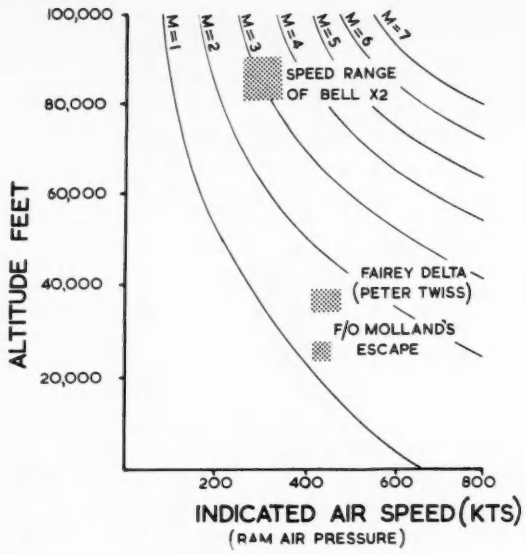
At their final session the delegates wisely decided not

to meet again as a group for possibly as much as two or three years. Instead, they encouraged FAO to hold a series of meetings or symposia on individual subjects within their terms of reference. It is understood that the first of these, to be held probably during 1957, is likely to be on irradiation as a means of food preservation.

THE X-2 AND SUPERSONIC FLIGHT

On October 8, 1956, the Bell X-2 rocket aeroplane crashed on the Mojave Desert. This experimental research vehicle, launched from a mother aircraft, was stated to have reached heights of over 125,000 ft. and was capable of speeds of over 2000 miles an hour for short periods. Despite its relatively short endurance, such a performance enabled a valuable test programme to be carried out on the many aerodynamic problems associated with flight at high Mach numbers.* It may be asked why such investigations are carried out at high altitudes. This is due to the fact that the thrust requirements of any propulsion unit are directly related to the drag of the vehicle, which in turn, at any given speed, depends more on the air density than on the Mach number. Supersonic speeds, therefore, can be more easily attained at high altitudes. The relationship between Mach number and indicated air speed (in effect the ram pressure of the air), at different altitudes, can be appreciated from the diagram. It is interesting to compare the speed range of the Bell X-2 with that of the more conventional Fairey Delta aircraft piloted by Peter Twiss when he reached, in 1956, a true speed of 1132 miles per hour at a height of 38,000 ft. This was an official record according to the Royal Aero Club regulations. The speed of the RAF Hunter aircraft when Flying Officer Molland made his successful supersonic ejection escape is also shown. See diagram.

In the case of the Bell X-2 and similar aircraft, however, a very complex problem arises in the event of an emergency requiring abandonment of the aircraft by the pilot. The method provided in this case was by means of a pressurised capsule, or pod, in which the pilot was separated from the aircraft. In this way he was protected from the high-speed wind blast, at the time of separation, and also from the effects of anoxia and bends which could incapacitate an exposed pilot within a few seconds at such heights. Emergency pressure-suits worn under these conditions are a second line of defence, but would afford minimal protection against extreme cold and wind blast. For example, at a speed of Mach 1 at ground level the ram pressure of the air is approximately 13 lb. per sq. in. Once the escape-capsule has separated, it is subjected to tremendous aerodynamic loads at high speeds. Unless immediately and adequately stabilised, it is known that uncontrollable tumbling and spinning would very rapidly exceed the limits of physiological endurance. It can also be appreciated that in any vehicle using tremendous thrust at maximum performance to maintain its speed in level flight, a sudden power cut removing this thrust energy would lead to a forward deceleration due to the unbalanced drag of the vehicle. An object such as an escape-capsule with aerodynamic lines very much inferior to those of the aircraft from which it was separated might be subjected to deceleration forces a great deal higher, and may equal those of a crash impact deceleration, particularly if a drogue parachute is employed for stabilisation. The work of Paul Stapp on his rocket-powered deceleration sled at Muroc, so much publicised in 1956, has a direct bearing on this problem.



Such, then, was the engineering task which faced the designers when provision for escape was made in this aircraft. The system was, in effect, purely experimental and, as has been announced, it almost succeeded. Details of the chain of events leading to the emergency have not been released, neither have the full details of the attempted escape. Nevertheless, it appears that capsule separation did occur at this great height, but the pilot, Captain Milburn G. Apt, was unable to carry out all the further actions necessary before hitting the ground. This fatal accident should contribute a very great deal to the knowledge of the designers of similar aircraft in the future. In the light of this unfortunate incident it should be possible now to design a more certain means of escape for the conditions of high-speed and high-altitude flight.

* The Mach number can be defined as the ratio of the speed of the aircraft to the local speed of sound.

ENERGY FROM THE SEA

J. H. M. SYKES, Assoc.I.E.E.

The recent World Power Conference showed clearly that in spite of the practical development of atomic energy as a means for electrical power production, it is still necessary to concentrate every possible effort on the exploitation of any kind of natural resource that can be harnessed for this purpose. The world usage of energy in every form is increasjng at the rate of about 4·5% per annum, but the demand for electrical energy is increasing at a rate almost double this figure. The present rate of increase of demand will lead to a doubling of the world's electrical energy consumption in nine years instead of ten years, as has been generally supposed during the past decade.

According to figures from the general statistical section of the World Power Conference, the electrical power consumption of the world was estimated at 1,345,000,000,000 units in 1954, and the demand in 1958 is estimated to be such as to require 455,000,000,000 more units by that year.

About 60% of this increased supply of electrical energy will have to come from thermal power plants, burning coal or oil, and 39% from hydro-electric plants; it is expected that nuclear power will supply about 1%. Only in Great Britain will nuclear power production attain any significant figure (of above 1%) of power production within the next two decades.

Regarding the two main sources of power—the burning of coal and oil, and the exploitation of the energy in falling water—there is an increasingly strong argument against using irreplaceable fossil fuels purely for their heat content. In any case, in several countries, including Great Britain, the problems of extracting greater amounts of coal to meet not only the increasing electrical energy demand but also the requirements of industry, are rapidly becoming more serious. In other countries there are ample supplies of coal, but labour and other problems may be imminent, similar to those which we have had in this country.

The hydro-electric situation shows vast inequalities between countries in regard to their available water-power resources. In some countries, Switzerland and Sweden for example, the situation has already been reached that all the exploitable water-power resources have either been harnessed already, or are subject of definite plans to be carried out during the next ten or fifteen years. In other countries, such as the U.S.S.R., enormous potential water-power resources await exploitation, particularly in relation to the rivers of Siberia.

TIDAL POWER IS PRACTICABLE

Thus, in the absence of large-scale atomic energy plants in the next twenty years, there is urgent need to tap any other resources which may offer; and among the various projects for harnessing geothermal power—the temperature difference between the top and bottom of tropical oceans—wind power, solar energy, and a few other suggested sources of power, the idea of using the enormous potential energy production from tidal power schemes is by far the most practical and the nearest to commercial utilisation.

An estimate has been given that the whole tidal power of the world could produce 1,000,000,000,000 kW. This generating capacity, at a load factor (the proportion of fully utilised generating time to total time during a year) of 40% would produce 3,350,000,000,000 units each year. This is about three times as much as the world energy consumption in 1954. But, unfortunately, it is only possible to harness the tides at certain places where there is a high rise and fall between low and high tide water, and where suitable estuaries or straits permit of a dam being built to create a head of water which can be utilised for power production.

Nevertheless, such localities exist: and in view of the world energy situation it is of especial importance to learn that means to harness this new source of energy have been developed to the point where actual construction work on a major project has now begun. This point was reached in June of last year, when the French Government announced that the world's first tidal power project, at St Malo, in Brittany, had been authorised for completion.

Power-supply engineers have realised for many years the extent of the energy to be obtained from tidal power projects, and have formulated schemes, from time to time, to harness the sea for this purpose. The deterrent to the practical culmination of these schemes in constructional projects has, up to the last year or so, been of an economic nature and not one related to technical difficulties. The barrage across an estuary, such as the River Severn, would contain turbines and sluices which would enable the tide to flow in freely, and then, when the high-tide level had been reached on both sides of the dam, the sluices would be closed, trapping the water in the estuary.

As the ebbing tide lowered the level of the water outside the dam, the turbines could commence to generate power once a sufficient head had been created between the trapped water and the sea outside. The generation level would rise as the head increased, and then would decrease again as the tide rose. In this "single effect" method, power could be generated for about seven hours a day at each high-tide period.

Somewhat complicated methods, involving very considerable expenditure on double-basin dams and sluices, have been proposed to allow for a double-effect working: that is to say for generation to take place when the water-level is high on the seaward side and low in the estuary, and also when it is high in the estuary and low outside. The basic problem, however, has remained: the fact that energy is only available from such schemes at periods which vary each day with the tidal cycle, and are thus not coincident with the needs of the system. Tidal power schemes of the "conventional" type would therefore only be regarded as fuel-saving devices; other

plants would have to continue to be built to meet the peak loads.

FRENCH WORK ON TIDAL POWER

The French developments, which were the subject of a number of papers given to a recent conference on Energy from the Sea organised by the Société Hydrotechnique de France, which the present writer attended, and which included a visit to the tidal power model at St Malo and the site of the Rance *marémotrice* plant, have been such as to obviate at last this basic defect (from the electrical supply point of view) of tidal power projects.

The advance in engineering technique which has enabled this major step forward to be taken relates to the design of a type of water turbine which can act both as a pump and a turbine, and can perform both these functions with the water-flow in either direction.

The conventional hydro-electric generator for low heads is of the Kaplan type, in which a vertical shaft is employed, the alternator being above water-level and the runner being generally similar to a ship's propeller. The blades, however, are arranged so that they can be feathered to allow for differing conditions of head. The water is led to the blades through a snail-like tubular passage, flowing inwards past the blades and then vertically downwards to the draught tube and the tail water.

This type of construction would not easily lend itself to a tidal power project, and, moreover, the shape of the water-passages would not allow such machines to be used for the free passage of water through them without power generation.

The bulb type of machine consists essentially of a horizontally disposed Kaplan runner, with its variable pitched blades, coupled directly to an alternator, which is enclosed completely in a sheet-steel sheath so that the whole unit can be submerged in a horizontal tube cut in the dam structure. The passage of water through the tube, owing to the streamlined shape of the generator bulb, is hardly affected by the presence of the generating unit if the blades are in the fully feathered position, that is to say, with the line of the blades in line with the water flow. Thus, very considerable simplification in civil engineering work was made possible. In addition, the unit could be made to operate with practically the same efficiency whether as a generator or as a pump, in the latter case the generator turning into a motor and drawing power from the system.

There were, however, certain difficult problems to solve. The operation of any large electrical generator involves the production of a great deal of heat through losses in the conductors and in the iron of the magnetic circuit. The heat created by these losses has to be evacuated, and means for circulating a large volume of air through the bulb unit in its totally immersed situation had to be developed. This took the form of streamlined trunkings acting also as supports for the unit, and so designed as to offer the minimum obstruction to the water flow. The problem of corrosion was also one which the designers had to overcome, and here the use of special steels was found necessary. The control mechanism for the variable-pitch blades has been established for many years in connexion with Kaplan turbines, but in the conventional type of machine the shaft is hollow and the control gear for the servo-mechanisms operating the blades is situated within the shaft, the operating part being normally at the top of the unit, well clear of water-level. In the case of the bulb-type units, this operating mechanism had to be brought out in a direction vertical to the shaft, thus posing some difficult mechanical problems.

The bulb-type unit, which has been used experimentally over the last five years in French hydro-electric schemes of the run-of-the-river type, can operate on heads varying between 10·75 m. and 3 m., and can be used, as mentioned above, as a generator, as a pump, or as a straight-through valve—an advantage not possessed by any previous design of hydro-electric generating units.

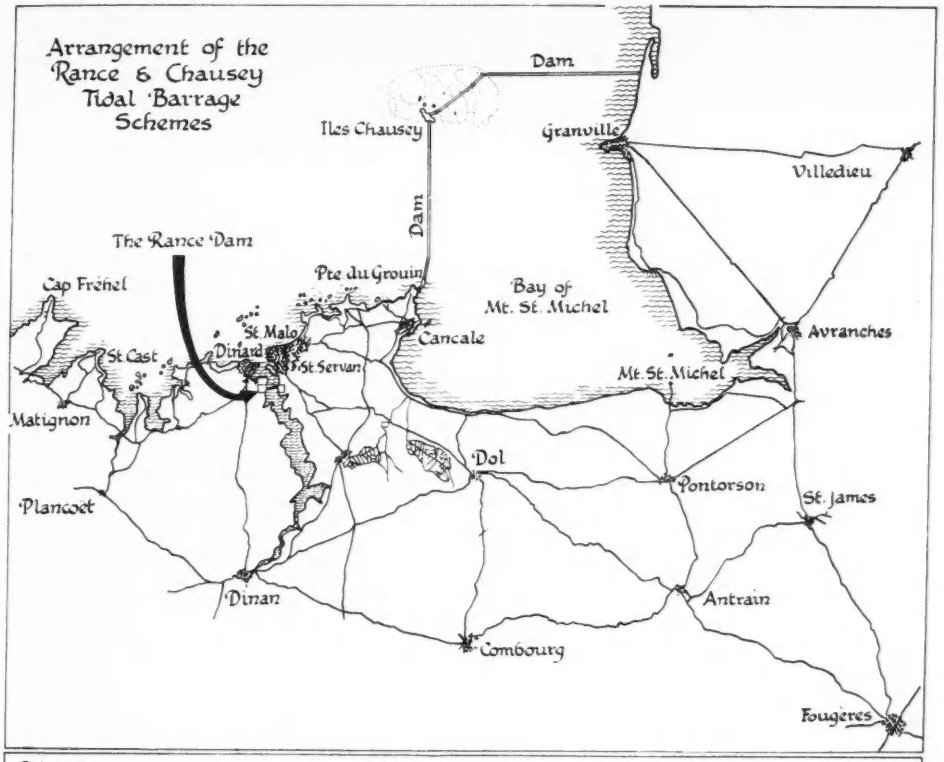
The principle by means of which the time limitation of conventional tidal power schemes has been avoided is to use pumped storage of water to control the time when generation can take place.

Any thermal power station runs most efficiently at a steady full load, and in consequence there are many periods of the day when power stations of this type may well be running inefficiently, since they have to meet the load as it arises—and during the night hours, particularly, the load is usually only one-sixth of the peak load during the day. Thus it is an economic proposition to "lend" energy during off-peak periods, to receive it back at peak periods; and pumped storage, as the method of storing electrical energy in a hydro plant by pumping water from a lower level to a higher level during off-peak hours is called, is becoming increasingly important in the electricity supply world. This principle, now being applied to the tidal power project on the River Rance, will be the key to its economic success.

THE CYCLE OF HIGH-TIDE POINTS

With the aid of the diagram, the cycle covering two high-tide points can now be traced out. Assume, as in Fig. 1, that the tide water has been allowed to flow through the dam so that the levels are equal inside and outside. If energy is available for pumping, the turbines can be turned into pumps (Fig. 2), thus raising the level of the water in the estuary to an artificially high level, as the tide falls outside. Then, when a suitable head or difference of level between the inside water and the sea outside has been attained, as in Fig. 3, generation can take place, the water flowing outwards to the sea. As the level inside has been artificially raised, it follows that generation can continue for a longer period than would be the case if the water in the estuary were only at high-tide level.

All water turbines require a minimum head, in this case about 10 feet, to operate, and when the generating operation has lowered the water-level so far that generation is impossible, the turbines can be turned into valves and allow a free flow of water from the estuary to the sea (Fig. 4). Other sluice gates, situated at the two ends of the dam, are also opened to assist in evacuating the impounded water as rapidly as possible.


Arrangement of the Rance & Chausey Tidal Barrage Schemes
Dam
Iles Chausey
Granville
Villedieu
Dam
The Rance Dam
Cap Frehel
Pte du Grouin
Bay of Mt. St. Michel
St. Malo
Dinard
Cancale
Avranches
St. Cast
St. Servan
Mt. St. Michel
Matignon
Dol
Pontorson
St. James
Plancoet
Dinan
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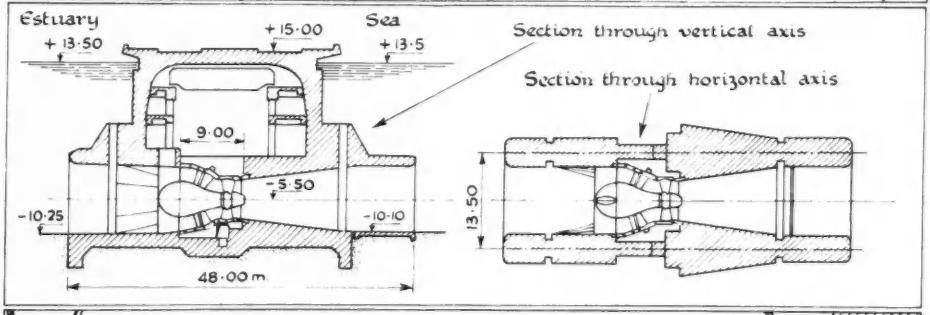
Estuary
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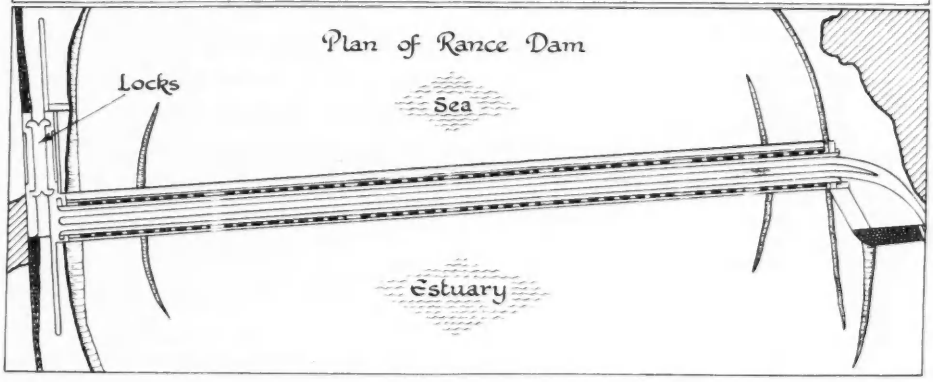
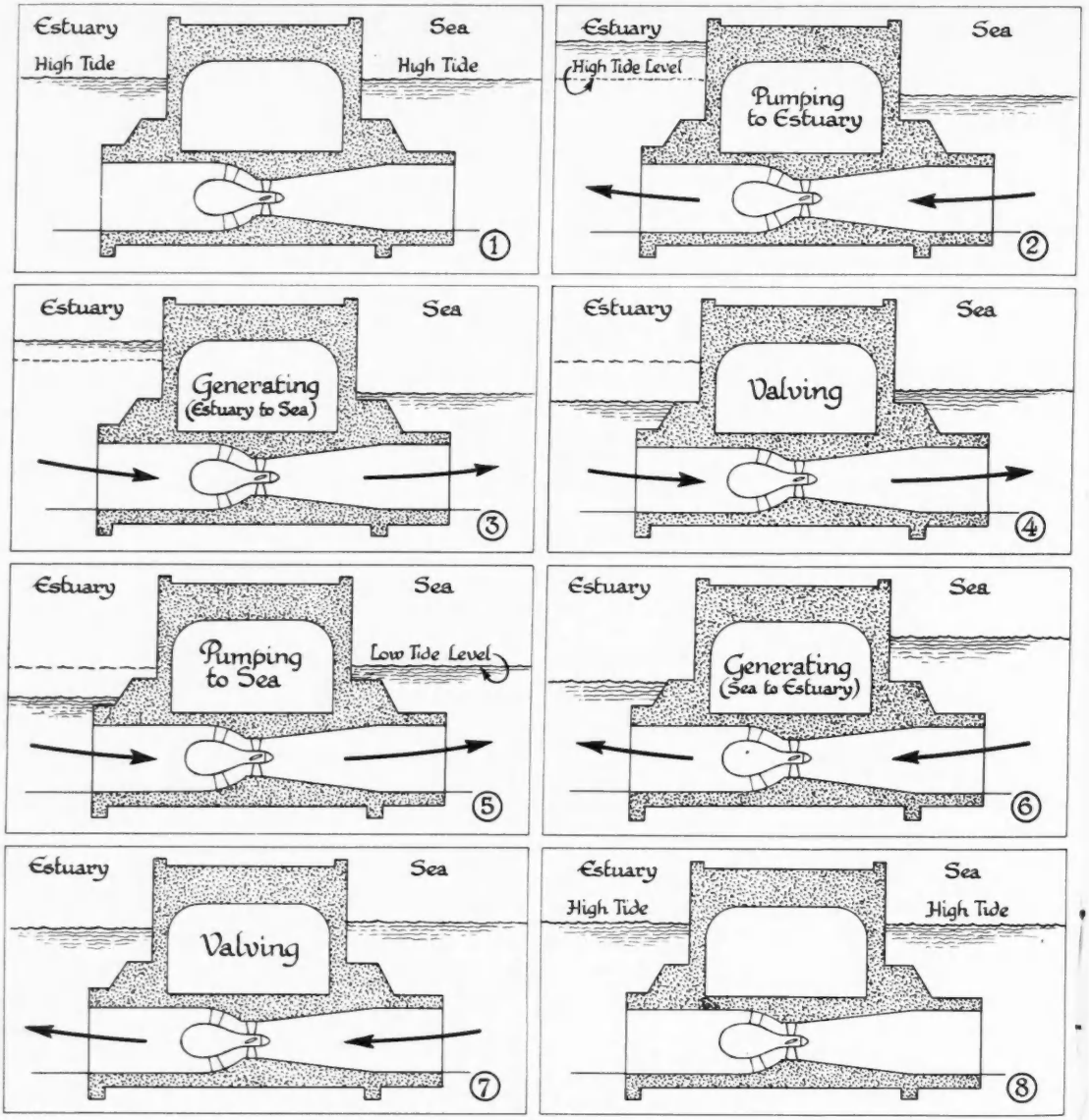

Plan of Rance Dam
Locks
Sea
Estuary



Details of the water-flow cycle through the tidal power station. (*Copyright* DISCOVERY.)

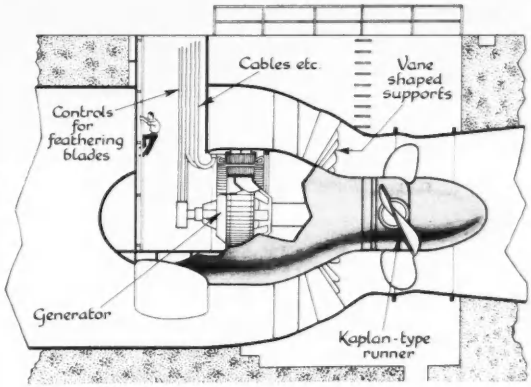
Once the water has flowed through these "valves" until the natural equilibrium of levels has been reached, once again pumping may be employed (if energy can be made available at that time) to lower the level of water within the dam to an artificially low mark, as indicated in Fig. 5.

In Fig. 6 the condition is shown when the tide water outside the dam has again risen, and generation can once more take place, this time with the water-flow from the sea to the artificially low level within the reservoir formed by the estuary. Again, as in the generating operation in the reverse direction, the period of energy production can be prolonged when compared with the similar period available if an artificially low level had not been created.

In Fig. 7 the level of the water within the dam has risen, through the generating operation, so far that there is no longer sufficient difference of head to permit of

generation, and the turbines are again feathered so that water flows through freely, to reach high-tide mark once again on both sides of the dam (Fig. 8). The whole cycle can then restart.

The important point to emphasise is that pumping energy, which is only available at off-peak periods (mainly during the night), can be utilised, whatever the state of the tide, to increase the subsequent period of generation. Thus, the whole cycle is capable of infinite variation, depending on the time relationship of the peak load and the high-tide points in each day. It is claimed that power can be made available to the supply system at the most valuable time—the time of peak load—on almost every occasion, irrespective of the state of the tide. It is peak-load power that is so valuable, since if the tidal power scheme could not produce power at peak load, then, as already mentioned, other plant would have had to be built, with high capital expenditure, to meet the peak. The capital costs of the tidal power plant would then become difficult to justify.



The bulb-type pump-turbine as used in the Rance tidal project.

THE RIVER RANCE PROJECT

The actual project on the River Rance takes the form of a hollow concrete dam resting on a solid rocky bottom in the river-bed (a fortunate circumstance for the designers) and extending for a distance of 2932 feet from side to side of the river, about 2 miles south of the port of St Malo. It will be 157 feet wide, and the upper hollow portion will contain the electrical plant, such as transformers and switchgear, and cranes for lifting out any one of the 38 generating units mounted in tubes 30 feet in diameter, the centre line of the tubes being 18 feet below low-water level. The tubes and generating units, therefore, are always completely submerged.

The dam will also be equipped with a number of sluices to aid the valving operation, in order that the water can be released in either direction as rapidly as possible.

The area enclosed within the dam, comprising the estuary of the Rance as far as Dinan, will amount to about 7¼ square miles at high-tide level.

The 38 generating units, each of 9000 kW capacity, will provide a total power output of 342 MW, and it is estimated by the designers that the Rance scheme, when it is completed in 1960, will contribute 800 million units of electricity to the French supply system.

The planning of the Rance scheme has been greatly aided by a model, inspected by the writer during the conference, which is situated at St Malo and covers the very large area of one acre. On a flat concrete surface, under a corrugated-iron roof, the whole estuary has been simulated, with concrete banks and river-bed, the length of the model being 492 feet and its width 58 feet. Ingenious electronic devices have been developed to control the electric motors driving pumps to simulate the tidal ebb and flow, and in this way experiments have been carried out since March of 1955 on such problems as the probable effect of the dam on the silting-up of the port approaches, and the effect of the currents caused by the discharging of water through the sluices and the turbines. A lock is provided in the dam, on the west bank, for navigation, and the action of this lock and the operating problems at various conditions of water within and outside the dam have also been exhaustively studied.

The tidal power project at Rance will not only serve as a valuable additional source of power for the French electricity supply network, but in addition it will act as a pilot plant for the study of many of the problems of harnessing the tides on an even larger scale. During the conference there was an opportunity to visit the site of a project enormously larger than the Rance scheme. It envisages the closing-in of the Bay of Mont St Michel, thus requiring a dam 23·4 miles long, which would control the ebb and flow of tidal water in an area of between 270 and 308 square miles, which is about twice the size of the county of Rutland. The dam would run due north from the Brittany coast to a small collection of islands, known as the Îles de Chausey, and then it would strike out due east back to the mainland. This project would have a generating capacity of 8 to 10 million kW, and could produce about 25 billion units of electricity per annum, or about half the total demand in the whole of France at the present time. It would take fifteen years to build.

A BRAKE ON THE EARTH

An interesting point raised in one of the papers presented to the conference was the fact that since the basic energy source in a tidal power project arises from the rotation of the earth and the relationship between the Sun, the Moon, and the Earth itself, the artificial obstruction offered to the huge masses of water moving across the Earth's surface as the tides ebb and flow would act as a brake on the planet's rotation. It was estimated that if 1000 million kW of energy were abstracted from the tides by vast series of barrages, the rotation of the Earth would be so affected as to cause the loss of a complete day in each two thousand years.

SPACE TRAVEL AND AGEING

A correspondence between SIR RONALD FISHER, F.R.S., and PROF. W. H. McCREA, F.R.S.

We print below a letter from Sir Ronald Fisher to Prof. McCrea, and the latter's reply. These two letters refer to a correspondence which enlivened the columns of NATURE* *a few months ago. There Prof. McCrea and Prof. Herbert Dingle disputed the truth of a statement which appeared in Sir George Thomson's book "The Foreseeable Future". This said that a person who ventured out from the Earth for a long journey in a space-ship would find, when he returned after several years, that he had aged less than the people who had stayed at home. In other words, space travel might be a way of putting off old age.*

This notion has its roots in the theory of relativity, and, indeed, in those parts of it that were conceived of before Einstein's major work. Sir George Thomson's argument, which was inspired by Prof. McCrea, goes something like this. If a person on the Earth keeps some kind of contact—by light or radio signals, for example—with a space-ship moving away from him, he will judge that all the regular physical processes happening on the ship will go on more slowly than they would do on Earth. Clocks will appear to work more slowly than identical clocks on Earth, molecules will appear to vibrate more slowly, and human hearts will appear to beat less quickly. Then, to give what appears to be a paradox its twist, Prof. McCrea argues that the same things will appear to happen on the space-ship's return journey to the Earth. The result will be that when the traveller comes to compare his watch with that of those who stayed at home, he will find that it has ticked a smaller number of seconds away; by the same test, his heart will have gone through fewer contractions and he will not have grown as old.

In NATURE *Prof. Dingle made several criticisms of this argument, but perhaps the one with the most immediate impact ran like this: Just as the people left behind on Earth think that the traveller's clocks are running slow, so the traveller will think that terrestrial clocks and hearts are not ticking as quickly as his own. The result would be, says Prof. Dingle, that when the space traveller returned, both he and his relatives would be convinced that it was the other party which had cheated old age. But this would be an absurd situation. There must, says Dingle, be some flaw in McCrea's argument which, when corrected, would give everybody the belief that age had affected them equally. In other words, he says, travellers and stay-at-homes would age equally during the space-ship's journey.*

This argument drew in several complications. Some said, for example, that the great violence of the space-ship's acceleration at the beginning and end of its journey, and at the period when it turned round to set a course for home, would have played havoc with the time-keeping of its clocks. And it is certainly true that in most of the applications of the theory of relativity, there is no reason to suppose that two bodies which are in relative motion with respect to each other should be affected unsymmetrically. But Prof. McCrea argued that there would be an essential difference between a traveller in a space-ship and someone who stayed on Earth. For, he said, the Earth is submitting without protest to the Sun's gravitational field: it is "falling freely" under the Sun's influence just as Newton's apple fell freely under that of the Earth. (In relativity a body in free fall is said to move through space-time along a path, or "world-line", which is called a "geodesic".) The space-ship, on the other hand, has to make use of great and unnatural force to escape from the Earth's state of free fall into another which might carry it out to the most distant planets, and it has to do the same sort of thing when it turns for home, and again when it comes finally to rest on the Earth. This difference, Prof. McCrea argues, means that travellers and stay-at-homes need not be symmetrically affected by the journey.

The result of the correspondence in NATURE *has, however, been to stimulate uncertainty about this question, not to quell it. The main point of Sir Ronald Fisher's letter is to suggest a hypothetical experiment which will avoid some of the difficulties which beset the equally hypothetical experiment of the fast-moving space-ship. This, together with Prof. McCrea's reply, are printed below.*

University of Cambridge,
Department of Genetics.
May 10, 1956.

Dear McCrea,

I have been reading your correspondence with Dingle in *Nature*, and though I am not tempted to think that Dingle is right, it is not clear that you have made a clear case either, if your position is both that the time shift would be experimentally verifiable in an appropriate experiment, and that the principle of general relativity can be accepted in the form that "only relative movements of different material bodies are relevant to their physical experience".

In the latter part of your letter you contrast the world-paths of two possible observers, one remaining on terra firma whom you say describes a single geodesic, and the other who travels far and fast describing, in all, segments of four geodesics; but this "explanation" of the supposed absolute difference in their temporal history during their separation is not really fully satisfying if you consider that you in your chair and your clock on the mantelpiece are both supported against the force of attraction of the Earth, and are not really in a state of free fall such as the description of a world geodesic would imply. Of course g is not an intolerably great acceleration, but it would, in fact, be quite sufficient to allow the traveller to obtain very high velocities, so that instead of imagining him as suffering crushing accelerations for three short periods you could match his gravitational experience, that is to say, I suppose, his curvature in relation to geodesics, with that of the stationary observer on Earth.

Some people, in fact, do seem to attach great importance to these high accelerations, in the example discussed between you and Dingle, though I imagine you are not among them.

I should much like to know if you would agree in checking the purely kinematic situation implied by relativity theory, special or general, in a case a little more realistic than that which you discussed in *Nature*,

* *Nature*, 1956 ,vol. 177, p. 782 and vol. 178, p. 680.

namely to allow a vehicle to standardise its acceleration, or its gravitational field, in whichever way you choose to regard it, by hanging a weight on a good spring balance and using the engines as a servo-mechanism to maintain the pointer at a fixed level, so that subjectively the contents of the vehicle experience a constant gravitational field, and to study the effect of this on clocks of various kinds—pendulum clocks, vibrating quartz rods (and a beautiful caesium clock on the mantelpiece), as well as on organic clocks, let us say a sitting of eggs and a newly born baby, for the last of which it is to be observed at the end of the journey whether she is approximately 19 years old or 290. The kinematic specification of the journey then consists in maintaining the acceleration at 981 cm/sec^2 for five years (the year for this purpose being simply c/g), reversing the direction of the thrust for the next ten years, and reversing again at the fifteenth year, completing the journey at the end of twenty. People looking for catches are inclined to suspect any apparent discontinuities in the course of events, so that these changes may be specified as consisting of a short subjective time, say three or four minutes, coasting without the use of the engines, while a heavy flywheel, carried for the purpose, is turned through the necessary number of degrees to reverse the orientation of the vehicle. Some, however, may prefer to have an engine at each end, and so obviate any alleged time-disruptive consequences of this simple manœuvre.

The kinematic specification of the acceleration subjectively experienced implies that if any rarefied gas or dust is encountered, the engines shall take up the additional load without deviating from the kinematic programme laid down. All these precautions, in fact, are solely for the purpose of precluding confusion due to extraneous arguments which, experience has shown, enter easily into this question.

May I now assume it to be verifiable that the farthest extent of the proposed voyage would take the vehicle to a distance of about 140 to 150 light-years from its starting-point, that remarkable changes are observable in the colour of the Sun as viewed from the vehicle, and that terrestrial clocks will have advanced about 290 years, whereas the most juvenile passenger is still in her twentieth year? All the ship's chronometers agree excellently?

If that is the agreed quasi-observational basis, the various clocks in the vehicle having kept very good time with each other and with the biological phenomena also in progress, the time shift is not quite easily to be ascribed to the relation between the two world-paths, which begin and end together, and the world geodesics, to which at any time they are tangential. You would seem to need, also, some sort of reference, perhaps to a substrate, or perhaps to the large masses of very distant nebulae.

Anyway, I wonder if you can throw any light on the residual difficulties I have tried to indicate.

Sincerely yours,

RONALD FISHER, F.R.S.

(Written in U.S.A. as from)

Royal Holloway College,
Englefield Green,
Surrey.
June 12, 1956.

Dear Fisher,

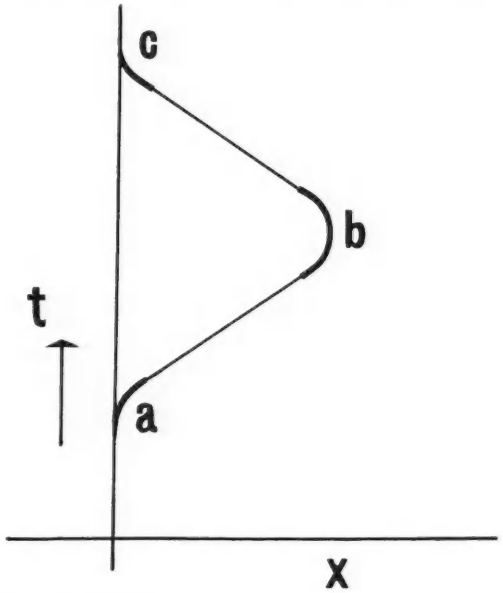
I think the main points in reply are:

1. I should not agree that the principle of general relativity can be expressed as "only relative movements of different material bodies are relevant to their physical experience" *unless* it be also accepted that in general the motion of A relative to B, as observed by B, is *not* the same as the motion of B relative to A, as observed by A. In fact, the point of my letter to *Nature* of several years ago, which Dingle now attacks, was to point out that the symmetry does not exist in cases where often people had unthinkingly assumed it to do. Since it does not, the clock paradox is not a paradox.

When proper provisos are made, I venture to think that the above statement of the principle of general relativity becomes not very meaningful.

2. The basic idea is, I suppose, that relativity does not abolish the notion of absoluteness. We consider a region of space-time to be represented by a region of a Riemannian 4-space. That 4-space is then something absolute. Relativity theory then proceeds to allow us to say what is observed by observers represented by, at any rate, some world-lines in the space.

3. We cannot specify the world-lines until we have the 4-space. Consequently, there is no meaning in saying that the time-shift is to be ascribed to the relation between two world-paths, if that is taken to imply that the world-paths have "relations" that depend only on themselves. Any relations they have depend necessarily



upon their relations to the 4-space. This is essentially the point that Dingle fails to see.

4. Certainly, as you say in your last paragraph, there is all the way a reference to a substrate. Physically, this is, again as you say, determined by the universe in the large.

5. From the standpoint of general relativity, the space-time of special relativity is not a case of no field, but, as Einstein pointed out, it is just a particular "field". The aggregate of inertial frames must be determined by this "field"—physically, by distant parts of the universe.

6. As regards the three accelerations you mention, these must be irrelevant since the "triangle" in the figure can be made any size we please using exactly the same "acceleration corners" *a*, *b*, *c* (see p. 57).

7. With regard to your second paragraph, I was, properly speaking, neglecting the Earth's field and thinking of the "engine" as required in order to escape from the Sun's field. That is, I was neglecting any effect of support against terrestrial gravity upon terrestrial clocks.

8. To come now to your major example. In relativity theory it is generally postulated that the proper-time measured by an observer with *any* world-line, using an "ideal clock" (see below), is simply the interval-length along his world-line.

Actually, there is a possible source of criticism here.

We suppose, of course, that we are dealing only with observers moving through empty space, i.e. not through a material medium.

Then the world-line of any freely moving observer is a geodesic. There is no doubt about the above postulate (within the framework of the theory) for such an observer. This is why I talked about observers whose world-lines are either geodesics or parts of more than one geodesic except for portions whose effects can be made irrelevant. So I believe that what I said is correct.

Where the possibility of criticism comes in is in the case of a world-line that is essentially different from a geodesic. For an observer can have such a world-line only if he is acted upon by some force other than gravity and general relativity does not, strictly, give means for dealing with such a force. So, taking the theory in its strictest form, it does not need to postulate what such an observer finds for proper-time.

Nevertheless, it is usual to extend the theory to the extent of applying the postulate to any observer having any (time-like) world-line. Only then is it necessary to say more carefully what we mean by an "ideal clock".

This can be seen by making use of your own example of the uniformly accelerated and decelerated laboratory. Here you evidently take space-time to be that of *special* relativity. In that case, I have verified that the postulate leads to the figures you quote, i.e. about 150 light-years and about 290 years in the description of the observer at rest in an inertial frame.

Now the observer in the accelerated laboratory will find things happening in his laboratory as though he is in a gravitational field of strength *g* and supported. Therefore he will have to use an ideal clock that can be regarded as being unaffected by this field. He can choose crystal clocks and caesium clocks, or even a wrist-watch, for which this assumption is valid to any desired accuracy. As to the young lady, if she is the sort that is accustomed to living at 1 *g*, her age will be 20, as you say. Had the acceleration been 2 *g*, biologists would have to say what the effect would be. But the effect would, in your example, depend only on the acceleration, not upon the speed relative to a particular outside observer. On the other hand, the time-shift between the observers *is* an effect of the relative speeds.

I repeat that this example needs this special discussion because it cannot be treated within the framework of strict general relativity (special or general).

Yours sincerely,

W. H. McCREA, F.R.S.

THE PENDULUM CLOCK OF CHRISTIAAN HUYGENS

R. McV. WESTON, M.A., F.R.P.S.

In December 1656, Christiaan Huygens made the first mechanical timepiece controlled by a pendulum. The unique timekeeping properties of the pendulum were first appreciated by Galileo in 1582, but it was Huygens who successfully coupled the pendulum to the clock.

The tercentenary of this important invention is being celebrated in the form of a small, but fascinating, exhibition at the Science Museum, London, organised jointly by the Science Museum and the Antiquarian Horological Society.

The exhibition is arranged in sections, and Section A contains some unusually fine early work. Mention should be made of No. 4, by Jobst Burgi, of about 1580–85. This clock is very remarkable in a number of ways, not least of which is the outstanding finish and excellence of workmanship. In Section B, No. 3 should be noted, as it is a pendulum clock dated 1656, of Italian origin. Section E contains some very early pendulum clocks, notably No. 1, of about 1660, by Bernard van Stryp, and No. 7, another early clock which may have belonged to Huygens himself.

From these early examples the visitor is shown more modern clocks, culminating with two superb examples of pendulum clocks of the highest attainable precision. One is from Greenwich Observatory, where it was in use until the end of 1925, and the other is a Shortt free-pendulum clock used there from 1925–42.

The exhibition marks the tercentenary of a fundamental invention in horology which is apt to be taken for granted today but was of the greatest practical importance.

An attractive and authoritative catalogue of the exhibition is available (price 2*s.*), and the exhibition remains open until February 24.

PHOTOGRAPHY OF THE DEEP-SEA FLOOR

A. S. LAUGHTON

National Institute of Oceanography, Wormley, Surrey

During the last decade, we have seen an enormous increase in the popularity of underwater activities stimulated by the skin-diving techniques that have opened up a new world to anyone prepared to don mask and "flippers". Hand in hand with this, the skill in underwater photography has revealed many fascinating glimpses into this new world. What is not so well known is the photographic exploration of the deep oceans, where only a very few men have ever descended, a world that is as different from the shallow margins of the continent as they in turn are from the land.

The first successful attempts at photographing the deep were made in America during the last war and many improvements have since been made. Now in England, at the National Institute of Oceanography, a new deep-sea camera has been made and during the summer of 1956 many photographs of special features of the deep sea were taken from the research ship RRS *Discovery II*.

DESIGNING THE DEEP-WATER CAMERA

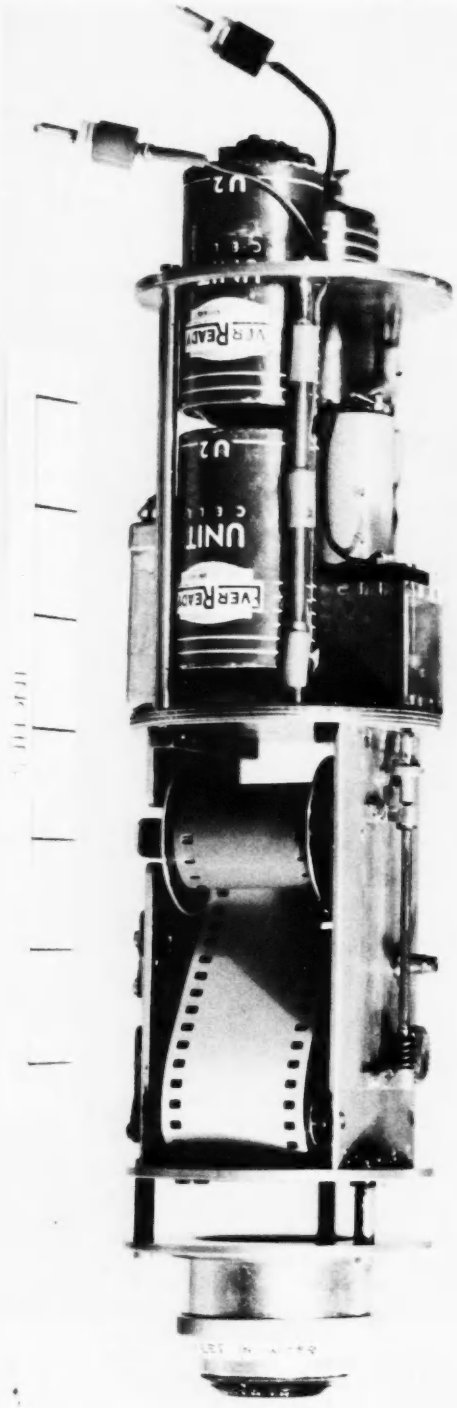
The problems of design of such a deep-water camera are more structural than photographic. A large proportion of the ocean floor lies at a depth of about three miles below the sea surface, where there is a pressure of three tons per square inch. It is therefore necessary to build cases for the camera and its accessories to withstand this pressure but at the same time to keep the whole unit small enough to be easily handled on board ship. The frame for the whole instrument is 8 feet in length, is just over 1 foot wide, and weighs only 90 lb. so that it can easily be carried around on deck by two people even though the ship is rolling (Fig. 1). This fact is an important one, since an instrument that can be easily used in rough weather is one that will be used. A camera station is the sort of work that can be fitted in well with other work.

The cases for the camera unit and for the flash unit are cylinders 4½ inches in outside diameter and with ¼ inch wall thickness. The picture is taken through a perspex window that is sealed, as are all other openings, by O-rings. The problem of bringing electrical leads through the pressure cases was solved by composite plugs of brass set into Araldite cement and machined accurately to fit into holes in the cases, again the final seal being done with an O-ring (Fig. 2).

The camera unit (Fig. 3), which can take up to a hundred frames on 35 millimetre film, has automatic film transport and triggering arrangements for firing the electronic flash that illuminates the scene. A special lens system is necessary to allow for the fact that the picture is being taken through a window, of objects which are in water. A lens is normally very carefully designed for use in air, but when used this way under water aberrations are introduced which have to be compensated by an additional correcting lens in front of the window. Since the camera is designed for use in the deep sea, where there is no light at all except for the occasional luminescent fish, we can dispose of a shutter and use the flash to determine the exposure.

A very real problem in handling any gear on the end of a wire in deep water is to know when you have touched the bottom. The weight of the wire is usually so much greater than the weight of the apparatus on the end that it is difficult to detect a change in tension of

FIG. 1. The author with the deep-sea camera before lowering. At the top of the frame is the "pinger" directed upwards, below it is the camera unit, and near the bottom is the light source. (*Photo: British Petroleum Company.*)



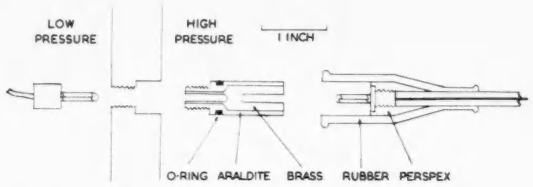


FIG. 2. (*above*) Diagram illustrating the method of bringing an electrical lead through a high-pressure case.

FIG. 3 (*left*). The camera unit showing the motor and gear drive for automatically moving the film between pictures. The lens points to the ocean floor.

the wire. When taking pictures of the bottom, not only do we want to know when we have taken a picture, but we also want to avoid the risk of piling wire on the bottom and of getting it fouled up. This difficulty is overcome by sending acoustic signals or "pings" to the surface from the camera. While the camera is being lowered, it emits one ping every five seconds and this can be heard on the ship through hydrophones and the camera can be followed down. When it hits the bottom, the pings are emitted at the rate of two a second and when this is heard the winch can be stopped and the camera raised a few fathoms. Successive raisings and lowerings at intervals of about a minute or two while the ship slowly drifts, give a series of pictures across the bottom. A sample is taken when the camera first hits the bottom and this helps to identify what is seen in the pictures.

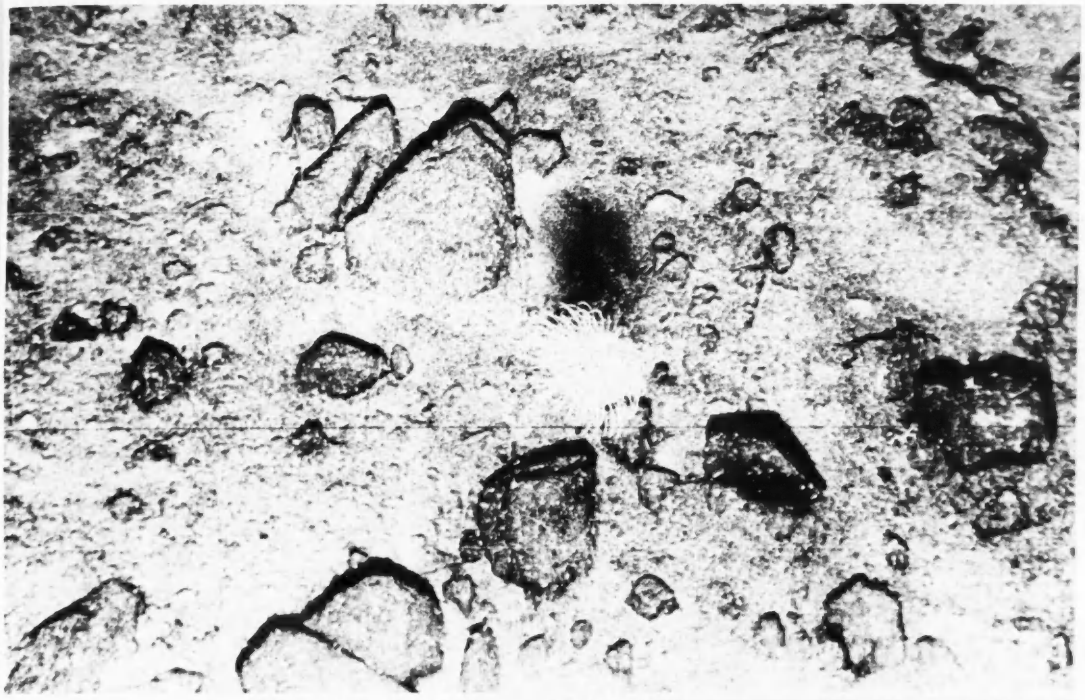
UNDERWATER MOUNTAIN REGIONS

By far the most interesting areas of the deep-sea floor to photograph are the mountainous regions which rise out of the wide flat plains. For here there are exposed rocks, volcanic lava flows, and sandy patches on which we sometimes find current ripple marks. Further than this, the abundance of living creatures increases as you come up out of the abyssal depths. At a typical station on a seamount, successive pictures may change from rock outcrops (Fig. 4) to sediment-filled depressions and again to slopes covered with loose boulders. Attached to the rocks we find a great variety of sponges and corals, and crawling along the sediment, numerous holothurians or "sea cucumbers". The deep, flat areas of the basins present a different scene. Here the continuous but exceedingly slow rain of sediment produces mile upon mile of relative flat unchanging scenery. In the soft oozes there are occasional animals to be seen, and their winding tracks are preserved for centuries. Often there are mounds and holes where bottom-living animals have burrowed into the ooze (Fig. 7).

Although one can get a good overall impression from a photograph, a detailed interpretation is usually rather difficult. One has to compromise between a picture that will give a panoramic view and one taken close to the bottom, which can give a detailed representation of the composition of the bottom. Sometimes pictures can be positively misleading, and an example of this occurred

FIG. 4. Rock e
top of a volca
at 5000 fee
Madeira. A
growing on th
the foreground

FIG. 5. Brok
lava flow from
volcano, lying
by deep-sea oo
The rocks sho
striations.



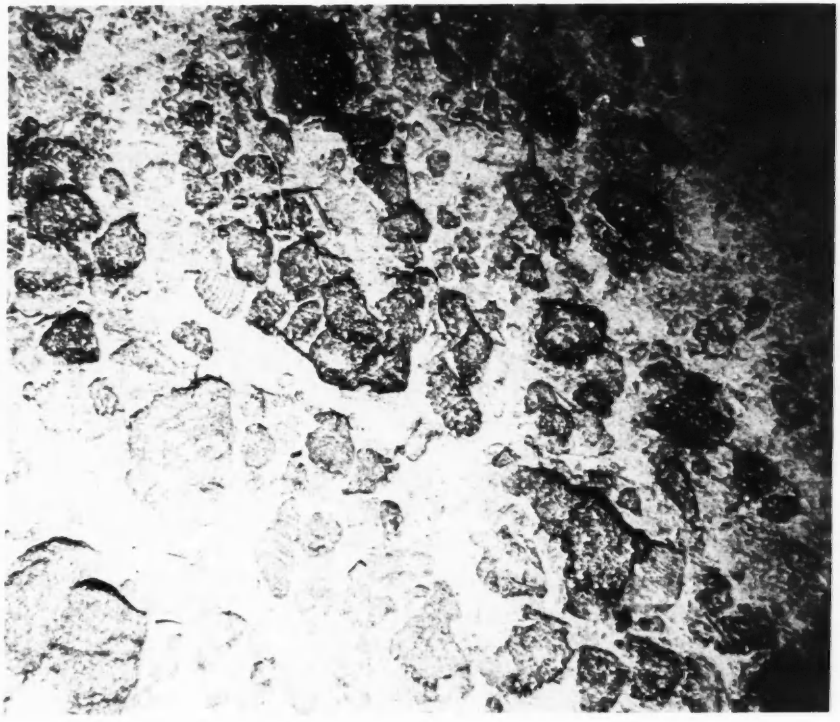


FIG. 4. Rock exposed on the top of a volcanic seamount at 5000 feet, north of Madeira. A gorgonian is growing on the boulder in the foreground.

FIG. 5. Broken pieces of lava flow from a submarine volcano, lying half covered by deep-sea ooze at 5000 feet. The rocks show pronounced striations.

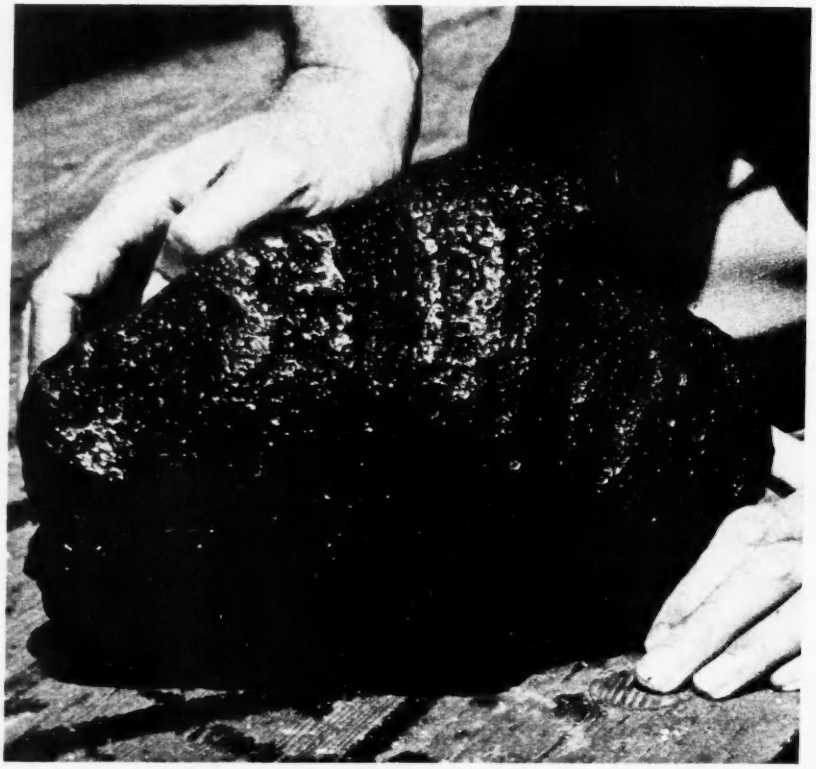
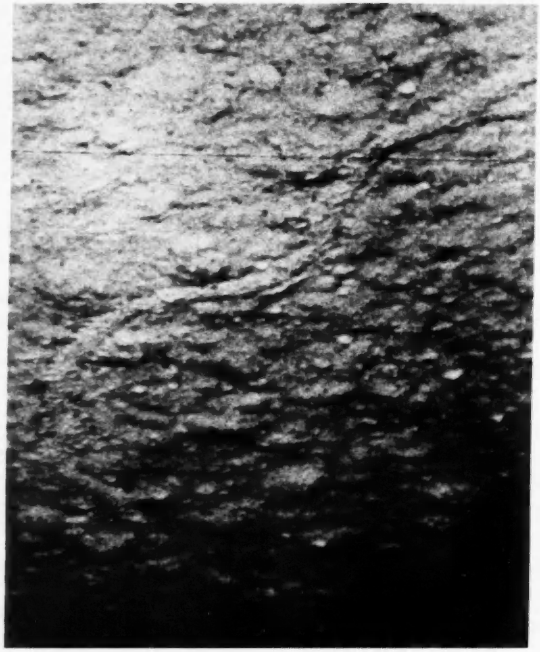


FIG. 6. A boulder of vesicular volcanic lava dredged from the same area as the photograph in Fig. 5, and showing similar corrugations. (*Photo: British Petroleum Company.*)

FIG. 7 (*below*). The flat bottom of an ocean basin 15,000 feet down. The various mounds in the ooze are made by burrowing animals, and the track across the picture is possibly that of a "sea cucumber".



during the summer's work. A picture taken near the top of a seamount (Fig. 5) revealed broken lumps of rock half buried by sediment. Nearly all of these rocks had markings on them which strongly suggested bedding planes that are found in sedimentary rocks. This would have been surprising in view of the theory that the seamount was volcanic. So an effort was made to dredge some of the rocks up from the same area, and we were successful in obtaining a sample which had similar markings (Fig. 6). This turned out to be a vesicular lava, and the corrugations on its surface appeared to be due to the rapid cooling of its surface as it flowed out underwater. The corrugations were further emphasised by being partially filled with sediment. This incident expressed the need for using the camera in conjunction with other studies of the bottom, especially sampling, so that a true picture of the bottom can be obtained.

Although we are now gaining a first impression of what the small-scale features of the ocean floor look like, we are anxious to extend the field of the photographs and to get a wider impression of the bottom landscapes. We are limited in achieving this by the scattering of light in the water from particles in suspension, giving an effect equivalent to a fairly dense fog on land. However, there is still much to be learned about the vast expanse of the sea floor, and every time the camera is lowered some new and exciting feature may be revealed.

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THE FERTILISING SPERMATOZOON

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Many fertilisation studies are carried out on sea-urchins, because their eggs and spermatozoa are easy to obtain in great numbers. Unfortunately, sea-urchin spermatozoa are smaller than those of mammals, which makes it almost impossible to see in any detail what changes take place in them after fertilisation. Apart from this, small structures are difficult to identify within an intact egg and it is therefore necessary to cut the egg into thin slices or sections to get the best out of the microscope with which it is being examined.

The sea-urchin spermatozoon can enter the egg anywhere on its surface; one section of the egg is, for this reason, unlikely to contain the minute spermatozoon for which one is looking; and even if it does, the section may well not pass through the spermatozoon at a convenient angle.

These observations apply to examination with the light microscope. Matters become even more difficult when an attempt is made to take advantage of the magnification and resolution possible with the electron microscope, the only instrument with which the fine structure of a spermatozoon can be seen. To achieve good resolution, sections must be not more than about 400 Ångstroms thick. As a sea-urchin is 1 million Ångstroms in diameter, more than 2000 sections would have to be cut per egg and kept for examination—an almost impossible task—to be certain of finding the fertilising spermatozoon in a section suitable for electron microscopy. Even then, as mentioned above, the plane of the section might well be such as to make the spermatozoon difficult to identify or reconstruct. To find out what effect fertilisation has on the spermatozoon, one must cut longitudinal sections of the spermatozoon before fertilisation, similar to those obtained by Afzelius (1955) and Rothschild (1956); but this was an easier task because for every spermatozoon inside an egg, there can be 5000 available for section-cutting when the sperm are in their pre-fertilisation environment.

My assistant Mr J. N. Thomson and I have obtained two sections of just-fertilised sea-urchin eggs, in which the planes of the sections were such that the fertilising spermatozoa were approximately in longitudinal section, Fig. 1. As this improbable event may not have been achieved before, the electron micrographs of these sea-urchin spermatozoa, three minutes after fertilisation, may be of interest.

Bearing in mind the dangers of generalising from isolated electron micrographs, the following changes in the appearance of the fertilising spermatozoon may be worthy of mention:

(1) Except in the region of the centriole, the nuclear membrane seems to have "dissolved".

(2) The centriole is double or has divided into two. (At some stage after fertilisation the centriole must divide into two.)

(3) The sperm tail, terminating at the posterior end of the centriole, is clearly visible within the egg cytoplasm.

(4) The middle-piece looks quite different after fertilisation. It is larger and more symmetrical, while its membrane is crinkly and discontinuous.

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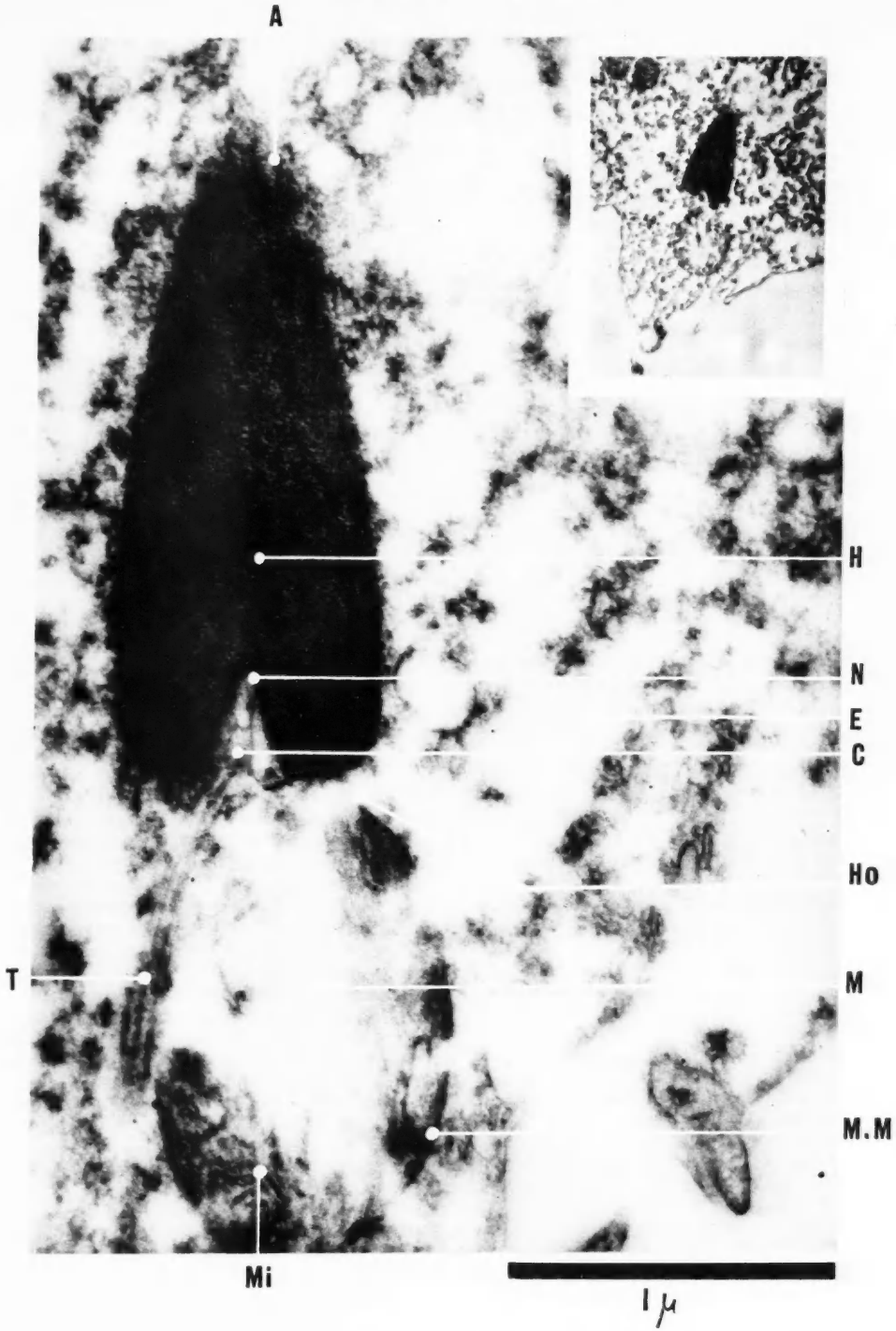
* This work is supported by the Medical Research Council. I am also greatly indebted to Mr R. W. Horne of the Electron Microscope Department, Cavendish Laboratory, Cambridge, for assistance in taking the photographs.

Spermatozoon of a sea-urchin (*Paracentrotus lividus*) within an egg, about three minutes after fertilisation: *A*, discharge acrosome; *C*, centriole; *E*, inside of egg; *H*, head; *Ho*, holes in middle-piece membrane; *M*, middle-piece; *Mi*, mitochondri in middle-piece; *M.M*, middle-piece membrane; *N*, remains of nuclear membrane; *T*, tail. Magnification, × 40,000. *Inset to right*. Another sea-urchin spermatozoon (*P. lividus*) just after fertilising an egg whose surface is visible. Note entrance con and enlarged middle-piece. The tail and centriolar apparatus are missing. Magnification, × 7000. The edge of the photograp is 5·7μ long.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"SCHOOLS LECTURES" AT THE ROYAL INSTITUTION

A NEW VENTURE

SIR LAWRENCE BRAGG, O.B.E., M.C., F.R.S.

Director of the Davy Faraday Research Laboratory, The Royal Institution

The Christmas Lectures for children at the Royal Institution have long been famous. Each series consists of six talks during the fortnight after Christmas which are "adapted to a juvenile auditory". For the most part the audience is composed of young people between the ages of ten and seventeen, though there is a good sprinkling of grown-ups amongst them who have come to enjoy the demonstrations. For it is the tradition that these lectures shall be illustrated by striking experiments on a grand scale. The lecture theatre, which holds 500, is liberally serviced for setting up experiments, and behind the scenes there is a large store of equipment of all kinds. The reputation of the Christmas Lectures is such that firms and other organisations willingly help by lending, or in many cases by making, special apparatus required for the demonstrations.

The first of these series was given in 1826–7 by J. Wallis on *Astronomy*, "illustrated by transparent scenery". Faraday gave them the next year on *Chemistry*, and between then and his last series on the *Chemical History of a Candle* in 1860, he was the lecturer on nineteen occasions. The last series, by Dr H. Baines, was on *Photography*. The Christmas Lectures have now been held for a hundred and thirty years and have had a considerable influence on the progress of science in this country. Many of the experiments, first devised for the Christmas Lectures, have become the stock-in-trade of school laboratories. On over thirty occasions the lecturer has subsequently written a book based on his course and they are among the best of our popular books on science. What is perhaps most important about these lectures is that many people, whether scientists or not, confess in after life that their interest in science was first aroused by attending Christmas Lectures at the Royal Institution.

THE "SCHOOLS LECTURES"

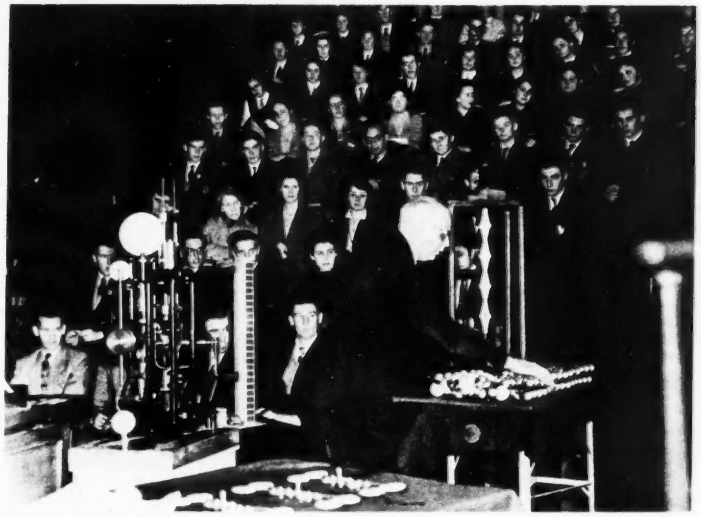
Encouraged by the tradition of the Christmas Lectures, we have embarked on a series of courses of similar lectures for young people from the schools in and around London, which are now given throughout the academic year. Most of the series of talks are given to pupils in their science sixth forms, others to pupils in the fourth forms, who have not necessarily all decided on a scientific career. We are helped and advised by representatives of the Science Masters' and Mistresses' Associations, and I think there can be no doubt of the success of the scheme. We show demonstrations and experiments illustrating the fundamental principles of science which are too large or costly to stage with school resources. Since the construction and assembling of the apparatus is a considerable undertaking, and much valuable equipment is generously loaned by industry, we wish to use it to the best advantage. We therefore repeat each talk four times and issue 2000 tickets for it. The tickets, for which no charge is made, are distributed to the schools by the Chief Education Officers in London and the Home Counties, who give us their warm co-operation. The scheme, which has now been going for three years, is still in the experimental stage, and is not on as large a scale as might eventually be possible because it takes time and money to collect the equipment and to design experiments which can be depended upon to "come off" in the lecture room. But we are planning to issue 16,000 tickets next year, and if the talks inspire an interest in science in a due proportion of the young people who come to them, their influence will be far-reaching.

THE ROYAL INSTITUTION AND ITS AUDIENCE

Such occasions are, of course, no new idea; similar lectures to children are arranged from time to time at many centres in this country. The Royal Institution, however, has certain rather special advantages. It has a central position, within a few minutes of Piccadilly Circus, so that it can easily be reached from anywhere within a twenty-mile radius. Its famous lecture room is ideal for the purpose and the Royal Institution buildings have an atmosphere of their own which contributes much to the success of any meeting held in them. The art of giving popular talks has long been studied here and the knowledge and equipment are available.

There is one feature about these lectures which is, in my experience, unique. The boys and girls attending each course are at the same stage in their education and so constitute an almost uniform audience. A point either goes down with all, or it misses fire completely; an experiment excites everyone in the theatre, or falls flat so that we resolve to do it differently next day. Normally, audiences include the clever and the slow, the expert and the non-expert, and one is torn between trying to suit the one or the other; this audience is "monochromatic" and offers a most exciting challenge to the lecturer.

The impression I have got from the lectures, and from our quite considerable and very encouraging fan-mail, is that these experiments supply a very real need. One appreciates to the full how much the teachers do, but limitations of school resources, the exigencies of the time-table, and above all the premium set on text-book



Sir Lawrence Bragg demonstrating to a typically youthful audience at one of his Christmas Lectures.

instruction by the demands of examinations, make their task a difficult one. An experiment which is shown in a few minutes to a class may take as many weeks to get into working order. Yet science is something one learns by handling matter and observing the results of experiments just as much as by reading books. The experiments the young people like best are often quite simple ones, as long as they are done on a generous scale. They are not impressed by large figures, or much impressed by utilitarian considerations. It is of no use to show them a spot of light travelling over a scale, or a meter moving, and telling them how hard it was to make it do so; they like seeing the works. Most of all they like an experiment which illustrates in a striking way some effect they can relate to everyday life, something they have all observed without understanding the cause. I think that here one is touching upon a rather fundamental feature of the British approach to science, and I would say of the American approach also, as contrasted with that of many Continental schools. We are happier with the concrete than with the abstract. We like thinking in terms of mechanical models. We prefer to start with particular cases, not with generalities. In my experience of research students from many countries, it has seemed to me that it is this practical bent which enables our students to hold their own as compared with the student from abroad who is often far more admirably equipped as regards wealth of knowledge and philosophical insight. And I fear that perhaps, with the pressure of crowded universities and schools and large classes, lecture demonstrations are fighting a losing battle to the great detriment of our science teaching. The lectures I remember most vividly as a student were the good old-fashioned ones, copiously illustrated by brilliant experiments.

The schools lectures at the Royal Institution have led to other schemes which have the same aim of assisting with the problem of science teaching in the schools. We arrange occasions when parties of science teachers meet the head of some famous research school and members of his team. The leader gives an informal talk on his projects, and for the rest of the afternoon the teachers divide into small groups and talk with the research workers, who have brought examples of their apparatus and results to show them. In this way the teachers hear something of the latest results of research and meet in a personal way the people who are doing the work. Another project we have in hand is to make the Royal Institution a centre to which the science teachers can come for help with their work. The library specialises in reference books, text-books and popular books on science, and has a wide range of periodicals. The lecture-room staff is expert in arranging demonstrations of all kinds, and can give the practical tips about details, and about getting the right materials, which save so much time and effort. We are setting up, with generous help from industry, a collection of demonstration apparatus of all kinds. Many of the sets may be too elaborate and expensive for schools, but they give ideas and show what can be done and it may prove practical to loan them on special occasions.

There is general concern at the present time about the difficulty of maintaining the standards of science teaching in schools. We hope that in these ways the Royal Institution is making an appreciable contribution towards easing the problem. It is an enlargement of its function, not a new function. The Visitors of the Royal Institution, meeting in 1827, recorded their "satisfaction at finding that the plan of juvenile lectures has been resorted to" and considered that "the system of instructing the young portion of the community is one of the most effective means which the Institution possesses for the diffusion of science". Our present aims are in complete accord with the aims of our founders, who were inspired by their love of science and their belief in its value to the nation.

THE GREEKS AND THE EXPERIMENTAL METHOD

BENJAMIN FARRINGTON

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It is the general opinion that modern science is a development of Greek science but differs from it radically in method. Ancient Greek science, it is said, was speculative, while modern science is experimental. I have come to think this distinction false. Greek science was a weaker growth than modern science, but there is no radical difference between them. For this view I propose here to make a case in the fewest possible words. The full argument would take a book.

To begin with, speculation is thought, wrongly, to be opposed to experiment. It is in fact the essential preliminary to the emergence of an experimental method. At the early speculative period of their scientific thinking, the Greeks produced a set of concepts in the absence of which experimental science could not have arisen. The earliest school, the Milesian, arrived at the view that there were four elements, Earth, Water, Air, and Fire, generated out of one another by processes of *thickening* and *thinning*. Heraclitus emphasised that this oscillation between Earth and Fire must be the result of a shifting balance of *forces*. The Pythagoreans thought that *structural pattern* must lie at the basis of different appearances of things. A line of development from Parmenides to Democritus clarified the concept of the *impenetrability* of matter; fundamentally there were two forms of existence, the Atom, which was completely impenetrable, and the Void, which was completely penetrable. With this concept the clear demarcation of Physics from Mathematics was achieved. Without these and other concepts defined in the speculative period, Science could not have arisen.

At a certain stage in these speculations the necessity for experimental demonstration asserted itself. Empedocles, by his reflections on his experiences with the "water-clock", had refined the conception of the element of Air. He showed that the invisible air is a substance which occupies space and can exert force. This was a turning-point in the progress towards an experimental method. It proved that there are forms of existence imperceptible by our senses, the behaviour of which can only be judged by their action on substances of a grosser kind. Anaxagoras came to the same conclusions by physiological observations. The bread we eat, by a process too refined for our senses, turns into a variety of other things—flesh, blood, bones, and so on. The Atomists generalised this in the famous phrase *Nature works by unseen particles*. After this there could be no progress that was not experimental in the sense of devising procedures by which the visible could be made to yield information about the invisible.

In the Lyceum at Athens and its offshoot, the Museum at Alexandria, we can trace the steps which led to the construction of a famous scientific instrument. It was the culmination of an inquiry persisting through three generations.

Aristotle himself proposed a fresh inquiry into the doctrine of the four elements. Complaining that the earlier thinkers had not considered the question of *how* the elements could change into one another, he undertook an inquiry into the various meanings of the word "change" in the course of which he clearly distinguished a *chemical combination* from a *physical mixture*. In a chemical combination, he says, the original substances lose their own qualities and produce a new homogeneous substance with fresh qualities of its own. He then draws up a list of homogeneous substances classified under the headings of mineral, vegetable, and animal. Finally he proceeds to subject each substance to the action of heat, cold, moisture, and various forms of physical force in the hope of being able to infer from their behaviour the elements of Earth, Water, Air, and Fire in their composition. It soon becomes clear that he is not asking questions that could possibly yield true answers. Nevertheless we have here a systematic physical investigation.

His successor, Theophrastus, not deterred by the failure of his master's researches, took up the inquiry afresh. As the result of an extensive series of observations he came to the conclusion that Fire ought not to be included among the elements, firstly because it is only brought into existence by some violent action of man or nature, and, secondly because it cannot subsist without nutriment. In short, Fire is rather a process than a thing.

The third head of the Lyceum, Strato, also investigated the elements, devoting special attention to Air. His procedure shows that he had realised the main mistake of Aristotle. Aristotle had given a purely qualitative description of the elements as compounds of the Hot, the Cold, the Wet, and the Dry. Strato based himself on the atomic view of matter and advanced the view that the elasticity of the Air was due to its consisting of atoms separated from one another by empty space. To establish his point he constructed a hollow metal sphere with a pipe inserted in it. With this instrument he made observations on the behaviour of Air when compressed and rarefied. He had, in short, an hypothesis about the nature of Air which he proceeded to the rank of a scientific instrument as that of Guericke. method as the right scientific procedure. His opponents he dismisses as "verbal gymnasts".

The sphere of Strato is, surely, at least as well entitled to the rank of a scientific instrument as that of Guericke. Indeed, if one reads the full account of Strato's experiments, one feels that it was nearer to Boyle's air-pump. Nor does it stand alone. The astronomers in Alexandrian times were using the *gnomon* and the *polos*, which they had borrowed from Babylon. To these they added another instrument of astronomical observation, the straight rod with the movable metal disc mounted on it,

by which they determined the angle subtended at the eye by the diameters of Sun and Moon. The measurements obtained in this way formed the basis of mathematical calculations of the relative sizes of Earth, Moon, and Sun.

In physiology we find the remarkable experiment by which Erasistratus, the friend of Strato, anticipated Sanctorius. Still concerned with the nature of the Air, he held the hypothesis that breathing was not a mere mechanical intake and expulsion of the atmosphere but a sort of slow combustion of the organism. He tested this out by weighing a chicken in a pot at intervals of time to see how much weight it lost by the mere process of living without nourishment. This measurement of a physiological process is striking.

Other examples might be adduced. There is the *aeolopile*, devised to substantiate a theory of the winds, but really revealing the force of steam; or the researches of Ptolemy into refraction; or Galen's endless physiological investigations. But perhaps enough has been said to suggest that Greek science did not differ in *kind* from that of the Renaissance.

A SOLAR BATTERY

JOHN GRIMROD

Until recently, only the thermocouple and the photoelectric cell have been available as a means of converting the sun's energy directly into electricity, and by their very natures these are capable of handling only minute quantities of power. A third device that can convert the sun's energy into electricity is the silicon solar battery which is under active development by the Bell Telephone Laboratories. It resulted from a fundamental programme of research on silicon and its possible applications in modern electronics.

Pure silicon has semi-conducting properties comparable to those of germanium, the material used for most transistors. Silicon has much greater electronic stability at higher temperatures than other semiconductors.

In the solar battery wafer-thin silicon strips about as thick as a razor blade are used, and the power derived by them from the sun is sufficient to transmit voices over telephone wires and to energise a transistor radio transmitter carrying both speech and music.

When the Bell solar battery was first demonstrated in April 1954 a 6% conversion efficiency was reported. This is much higher than that obtained with other photoelectric devices whose efficiencies have never been rated higher than 1%. Five months later, in October 1954, Bell scientists were able to announce that they had built experimental cells which yielded 8% efficiency. The latest solar battery has an efficiency of 11%, which is approximately half the maximum theoretical efficiency.

The solar battery and also other silicon devices developed by the Bell Laboratories depend essentially on a feature known as the "p-n junction", which is made by the controlled introduction of traces of impurities in the crystalline silicon.

Since the days in which semi-conducting crystals provided one of the several competing "wireless detectors", a competition in which the vacuum tube was the victor, research had been conducted into ways and means of making the erratic "crystal detector" reliable and reasonably efficient and capable of taking a leading role in extending the useful frequency range to higher and higher limits. In this study, the silicon to which the metal point was applied was found to be "spotty" indicating non-uniformity in the material then available. Although these impurities could not be detected chemically, it was found that careful freezing of the silicon, starting at the top of the melt and working slowly downwards, segregated the impurities so that a considerable part of the ingot would be sufficiently uniform for use in microwave detectors. It was also discovered that this process automatically produced in such ingots the first known p-n junctions, though as such they were still imperfect and inefficient. The p-type impurity in the silicon was identified as boron and the n-type as phosphorus. This made possible the

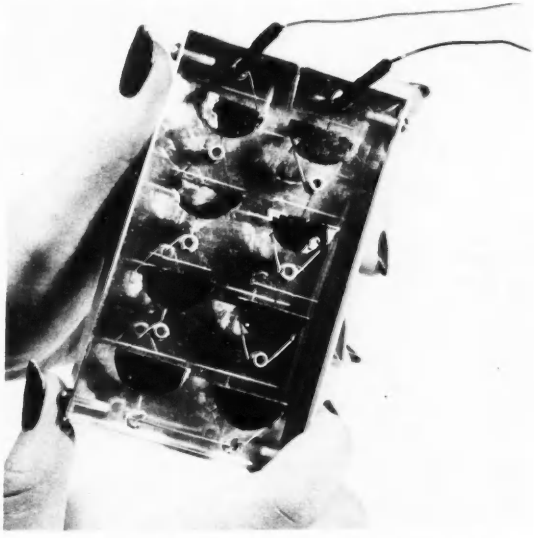


FIG. 1. A solar battery invented at Bell Telephone Laboratories is the first successful device to convert useful amounts of the sun's energy directly and efficiently into electricity. The battery, composed of strips of specially prepared silicon, has used the sun's rays to power the transmission of voices over telephone wires and to power a transistor radio transmitter.

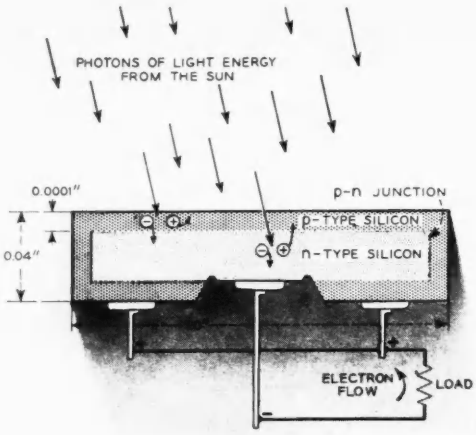


FIG. 2. Cross-sectional view of a plate of silicon prepared as a solar cell, illustrating creation of electron-hole pairs by photons of light energy.

manufacture of the first synthetic p-n junction by deliberately adding these impurities to molten silicon and by diffusing them into solid silicon. It was also found that other elements, whose electronic structures resembled boron and phosphorus, behaved similarly when added to silicon as impurities.

It was during post-war work on the physics of semiconductors that the point contact germanium transistor was discovered and the theory of the p-n junction became more completely understood. Researches made with germanium suggested that p-n junctions built into very pure silicon single crystals would perform many functions for which germanium, though more easily prepared in an extremely pure form, was not well suited, e.g. for all kinds of transistor action at higher temperatures.

The next step was to grow silicon as single crystals. Into the pure silicon single crystals, p-n junctions were introduced in a number of ways; one of which consisted of diffusing impurities into the surface of a silicon wafer. Using such diffusion junctions successful high-power rectifiers and lightning arrestors were made, while the same technique was developed to make the large-area solar battery.

This diffusion technique consists of heating the semiconductor wafer in the presence of a suitable impurity vapour. In this way, p- or n-type layers of controlled thickness are formed at less than one ten-thousandth of an inch below the surface of a thin slice of arsenic-doped silicon. Extremely sensitive to light these silicon strips can be electrically linked together to deliver power from the sun at 80 watts per square yard of surface.

Although work on the silicon solar battery is at the very early development stage, it is considered to have useful potentialities; for example, it might well prove a good way of providing power for low-power mobile equipment, and sun-powered battery chargers may find use as amplifier stations along a rural telephone system. Efficiency limitations are due, in part, to the fact that most solar photons in the infra-red are too weak to release electrons from the silicon atom and are wasted. Further research may, indeed, provide materials other than silicon that are more efficient converters of solar energy.

TWENTY-FIVE YEARS AGO: TELEVISION

From DISCOVERY, 1932, vol. XIII, p. 35

In "Notes of the Month" for February 1932 appeared the following:

"Notable developments in television are foreshadowed by the discussions now taking place between Baird Television Ltd and the BBC. The plans have not yet been revealed, but it is likely that the BBC will in future take a more active part in transmissions and that a wider choice of subjects will be available. Meanwhile, new plans for 1932 are announced by Mr J. L. Baird, who anticipates that large television screens will be displayed this year in places of entertainment. In an interview he described the improved apparatus recently developed, which includes a television telephone, enabling subscribers to see as well as hear each other. It is already in use in France, although not yet adopted on an extensive scale. According to *The Times*, two-way television between telephone-booths in New York has been successfully carried out, the images being very clear. But high-grade television is limited in its application, is expensive to maintain, and could not possibly be accommodated on the present broadcast wavelengths. Ultra-short wavelengths, however, are admirably suited for local television broadcasts, and it is now generally agreed that the television of the future will be accomplished by means of these waves transmitted from a tower or hill."

Baird Television Ltd followed this note up with an advertisement in the March issue, headed "Are you a blind listener?" "Are you content merely to *listen* to what is being broadcast?" they ask. "Is sound without sight enough for you?"

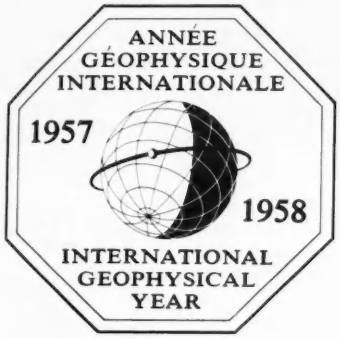
It is interesting that only recently, in 1956, scientists at the Bell Telephone Laboratories have developed a "picture-phone" on which persons talking by telephone can see each other on a plate similar to a small television screen. The picture-phone employs ordinary telephone wires, a relatively simple camera, and a two-by-three-inch screen which can be seen clearly from a distance of several feet. One of these instruments is now in use to link the Bell Telephone Laboratory in Beverly Heights, New Jersey, and the telephone office in New York. After further evaluation, the picture-phone will be offered as an optional telephone service.

The present picture-phone is not the first ever proposed, but is the first actually able to send images of the people at each end of the line through the regular telephone system.

THE INTERNATIONAL GEOPHYSICAL YEAR

MONTH BY MONTH

Compiled by Angela Croome



IGY Rehearsals Begin

There is to be a full-scale "dress-rehearsal" for the IGY during June, the month before the Year begins in earnest. All the observations and routines planned at scheduled stations throughout the world will be put in action.

A month will not be long enough for the communications network to be "run in". This network has to handle the transmission of alerts for Special World Intervals, for auroral warnings and solar flares, and for the tracking of the earth satellite. It must also communicate great volumes of data to the main distribution centres. The second week of every month until the Year starts has been designated a rehearsal period for the communications network. Last month (January) provided the first of these. Messages will normally travel by the means used for meteorological transmissions by the World Meteorological Organisation.

Four Regional World Centres have been established, with Fort Belvoir, Washington, acting as the World Warning Agency or "starter". The European Centre's responsibilities will be divided between The Hague and Paris. The other two such centres are to be the Institute of Terrestrial Magnetism, Ionosphere and Radio-propagation, Moscow, and the Kokobunji Station, Radio Research Laboratories, Tokyo. Some Associate Regional Centres are to be announced.

Soviet Rockets

More details of Russia's high altitude research programme for the International Year came out in an international symposium on rocketry that was held in Paris on December 3–8 by the Association for the Encouragement of Aeronautical Research. The Russians sent a delegation of twelve, most of whom appeared to be electronic men. There was one theoretical propulsion expert, but no one on the experimental side of propulsion. The delegation also included Dr Pokorovski, director of the Soviet Institute of Experimental Aeronautical Medicine, who described a successful series of rocket flights to heights of over 60 miles with dogs.

Most of the IGY work, it appears, will be carried out with rockets that have a ceiling of just over 60 miles, with a substantial payload of not less than 1200 lb. and probably considerably more. There was no direct reference to artificial satellites, and delegates would not be drawn on the point. The prepared statement did include vague reference to experiments that they hoped to carry out "up to heights of 1000 km.".

The words used were translated (from the French): "It is foreseen (and this concerns all divisions of our research) that the studies will be carried out at different altitudes up to heights of 1000 km. (620 miles) and at different geophysical locations, which are of the same high latitude." If the French text were a correct interpretation of what the Russians had intended to say, then this reference to "the same high latitude" would exclude satellites, since a satellite launched at a high latitude would normally pass over low latitudes. A rocket rising and immediately returning to earth would not do so.

Publications

The work on the IGY Manuals (which must be ready and distributed at latest by July 1, 1957) is proceeding under the General Editorship of Sir Harold Spencer Jones.

Copies of the Operational Manuals for the Antarctic programme were ready in time for the departure of the various expeditions. Temporary editions of the following Manuals have also appeared: Seismology; Longitudes and Latitudes; Antarctic Radio Communications; the volume on Geomagnetism; one on Aurora and Airglow; two volumes on the Ionosphere (vol. II. Ionospheric Absorption; vol. III. Drift Measurements).

Belgium Makes Twelve

The Belgian national committee is to mount an expedition to the Antarctic. This makes the twelfth country to undertake an IGY expedition to the southern continent.

The station will be operated between January and December 1958. Its location will be on the coast in the neighbourhood of 22° E. This will place it between the projected Norwegian and Japanese stations. The landing should take place in Breid Bay between 22° E. and 23° E. The following researches will be made: meteorology with aerological soundings and radiation measurements, geomagnetism (a complete set of equipment will be in use), auroral observations by visual means and with an all-sky camera (the station is close to the auroral zone), ionospheric measurements with a multi-frequency recorder, glaciology, specific problems in oceanography, and probably atmospheric nuclear radiation. At least sixteen people will winter at the station.

Commandant Gaston de Gerlache, of the Belgian Navy, is to lead the expedition. He is the son of A. de Gerlache, who led the expedition aboard the *Belgica* in 1898–9. In that year the *Belgica* was ice-locked off Graham Land and its expedition was the first ever to winter in Antarctica.

It was of particular note for several reasons. Henryck Arctowski, one of its members, observed that the Antarctic continental shelf was about twice as far below present sea-level as that of any other continent—200 fathoms (or 1200 ft.) instead of 100 fathoms (or 600 ft.). The question is: Why? The first of the most interesting fossils to be discovered in the sandstones on Snowy Hill and Seymour Island, on the east coast of Graham Land, was found by the expedition's artist, Stokes. The fossils were shown to be warm-water forms closely related to those of southern India; they thus provided the earliest evidence to be found of a tropical period in Antarctica's pre-history. The coal observed in South Victoria Land by British expeditions which provides similar evidence of a tropical period was not discovered until several years after the *Belgica* expedition.

Slow Work at the South Pole

Soon after the preliminary landing by U.S. aircraft at the South Pole, as reported in last month's notes, a small team of men was landed there and set about putting up the buildings for the main party. Unfortunately progress has been slow. Extremely low temperatures made it necessary to halt building activities for a while, and there was also some trouble because several canisters dropped from the air were buried in up to 15 feet of soft snow.

Dr Paul Siple will be in charge of the South Pole station. He is a veteran of the Antarctic. Ever since he was an Eagle Scout in his teens, he has accompanied Byrd's expeditions south.

Captain Finn Ronne, who is to lead the Weddell Station, also has a distinguished Antarctic career; he was first in the Antarctic in 1939–41 when the U.S. Government sponsored a surveying expedition. In 1946–8 he led his own expedition to the Weddell Sea area, and it was this expedition which finally proved that there was no strait connecting the Weddell and Ross Seas. The high land that blocked the way

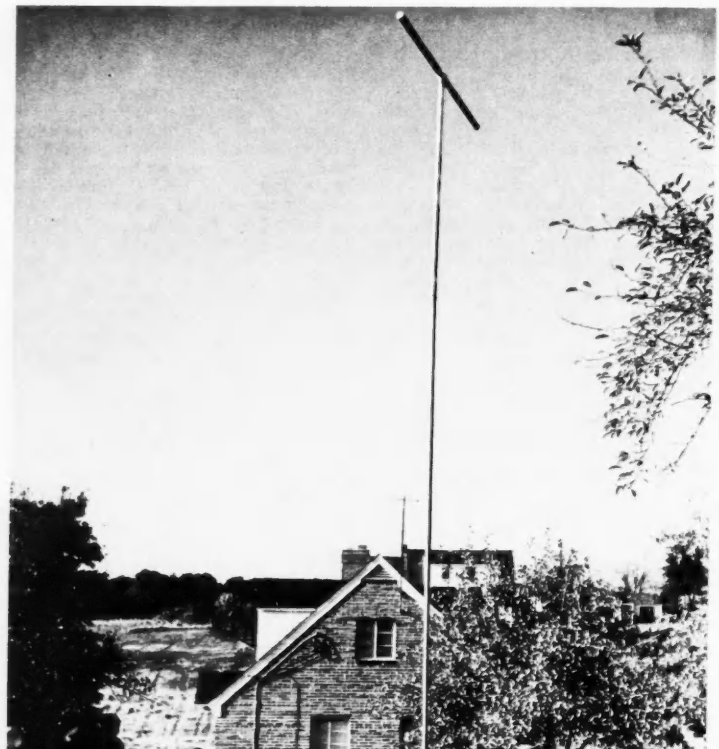
southward was named Edith Ronne Land.

It is appropriate that Dr Albert Crary, who is to take charge of Little America, is a distinguished meteorologist, as this station is to run the Antarctic Weather Central. Dr Carl Eklund will command at the Vincennes Bay base. Dr Siple has been appointed deputy to Rear-Admiral Richard Byrd, who is in overall charge of the U.S. Antarctic activities.

At the end of the year it was announced that Dr L. M. Gould had been appointed Director of the U.S. Antarctic Scientific Programme. He has been chairman of the Antarctic Committee since its inception. Dr Gould is a distinguished geologist and explorer and was second-in-command on Byrd's 1928–30 Antarctic Expedition. The scientific staff embarked for the Antarctic in U.S.S. *Curtiss* on December 27 with Dr Gould.

At the time of going to press, news of the arrival of almost all the Antarctic Expeditions has come in. Details will appear in next month's issue.

After an exciting voyage *Magga Dan* has succeeded in relieving both the Royal Society base and Shackleton base.



At his home in Silver Springs, Maryland, G. R. Wright (leaning over timing control box) set up this Satellite Observing Station. Mr Wright is Chairman of the National Advisory Committee of the U.S. Satellite visual observing programme. This photo was taken during a station team drill in October 1956.

Satellites to Multiply

On December 14 the U.S. National Advisory Committee for Aeronautics announced a plan to eject balloons from the *Vanguard* rocket that will launch the earth-satellite, in such a way that one or more of these will also travel in an orbit round the earth: in other words, become "sub-satellites". The "sub-satellites" will be inflatable spheres of plastic; they will blow up automatically upon ejection from the rocket, and when fully expanded will have a diameter of 20 inches, the same as the primary satellite. A sub-satellite will weigh only 10½ oz. It will be coated with aluminium paint to give it maximum visibility from the ground.

A "sub-satellite" will follow the same path as the primary satellite, but no information is yet available about its likely lifetime in the sky.

The committee said that the sub-satellites will be "valuable in measurements of air density in the extreme outer limits of the earth's atmosphere". As the sub-satellites (in contrast to the satellite proper) will contain no instruments, their value will depend entirely upon the information gained through tracking them from the ground.

It now seems as if the number of satellites projected into orbit by a single *Vanguard* will be at least two. Even if no sub-satellite is carried, the last section of the three-stage rocket should reach orbital velocity—18,000 m.p.h. at 300 miles high—in the course of boosting its "passenger" to this speed. In this case it, too, will become a satellite in its own right—as Dr Milton Rosen pointed out in a recent paper.

The week before the announcement of the sub-satellite project, the first test was made of the satellite vehicle itself from Cape Canaveral, Florida. This was, in fact, a single-stage rocket similar to the *Viking*; the final *Vanguard* will have three stages, of which the first stage, and the guidance system located in the second, will owe much to the *Viking*.

December's test rocket attained a height of 125 miles and a maximum speed of 4000 m.p.h. After seven-and-a-half minutes flight and at a height of 50 miles, the instrument-filled nose-cone was ejected. In this was the radio-transmitter, similar to that to be used by the satellite, and this was tracked by scientists from a position near the launching site.

The specifications for the first stage of the final *Vanguard* vehicle is that it should, in two minutes, reach an altitude of 40 miles and a speed between 3000 and 4000 m.p.h. If it is assumed that the nose-cone was separated on the upward journey, it is clear that the test rocket failed to meet the specifications. If the cone was ejected during the downward path of the rocket, however, the interval of seven-and-a-half minutes between launching and ejection becomes more comprehensible, and would, in fact, be consistent with the required *Vanguard* schedule.

View across the caldera of Kilimanjaro showing several large residual ice masses looking like stranded icebergs. The caldera scarp may be seen at the top right, and the slope of the inner core of the volcano at the top left. In the ice near the front of the picture can be seen vertical fluting from ablation, akin to what is known as *nieve penitente*; also the seasonal banding. *Nieve penitente* ("penitent snow") was first observed in the Andes and was so-called because its appearance suggested a ghost doing penance. (*Photo: Courtesy of Sheffield University Expedition to Kilimanjaro.*)

Besides providing flight data, the experimental firing also served to test new launching facilities at the Florida base. The test rocket finally plunged into the Atlantic 180 miles from the launching position.

Talking Round the World

At the end of 1956 the Radio Research Station, Slough, began operating an apparatus at Inverness, that in the course of some three years will fix the limits of short-wave frequency for communication between Britain and many parts of the globe. It is also expected to throw light on the nature of the ionosphere and its mechanism.

The apparatus may be described as a "swept-frequency oblique incidence recorder". The equipment is in two parts and may be compared with a pair of compasses of which the fixed foot is located at Slough. The "fixed foot" is a radio receiver. The other compass foot (now at Inverness) is a transmitter which directs short-wave pulses obliquely at the ionosphere over a wide range of frequencies. Transmitter and receiver, although hundreds of miles apart, are carefully tuned to sweep the same wavelengths at exactly the same instant. The variation in the signal then provides information about the state of the ionosphere and therefore about radio propagation conditions between Slough and Inverness. The signals are projected visually on a cathode ray tube, and a synchronised film-strip makes the record permanent.

The efficiency of the whole apparatus turns on the accuracy of the time-keeping. If the two parts are out of step by even a tenth of a second the results are useless. To ensure the necessary accuracy, two crystal clocks have been installed, one at Slough and one at Inverness. An accuracy in relation to each other to within one part in every hundred million has been achieved. Both transmitter and receiver are fully automatic and are, in effect, "triggered" by the clocks.

For three months the transmitter will remain at Inverness for what amounts to a test period. After that the transmitter will go overseas, first to Tripoli for about six months, then to Nairobi, and afterwards to Singapore. Other positions abroad may be selected before the experiment is considered complete.

Ice in an Equatorial Crater

In 1953 the Sheffield University Expedition to Kilimanjaro made expedition history by accomplishing more with less money than anyone seems to have done before. However, they returned to England with much left to be done. The mountain is about fifty miles in diameter at the point at which it rises out of the foothills. The expedition had accomplished a geological survey of the mountain's "outer skin" down to the 9000-foot line, but this could not give an adequate account of the mountain's geology. No final conclusions could be made about the extremely interesting residual ice in the old caldera of the

central volcanic cone of the mountain, because there were no sufficiently detailed recent records with which to compare the present state of the ice.

A second expedition to the mountain is to take place during 1957 to complete the work (see DISCOVERY, June, p. 249). Studies are to be specially made at the request of the British IGY committee. Chief among these is a glaciological programme to which some meteorological observations are necessarily linked; there is also a small geophysical programme.

A comprehensive study will be made of the several residual ice-masses within the caldera of Kibo (the highest central peak of the mountain, where there is still some evidence of volcanic activity). Though in 1953 some of these masses, which are scattered about the area like stranded icebergs, stood 200 feet high, they were obviously dwindling at an alarming rate. A photograph taken by a party that visited the area in 1912 shows the now nearly bare caldera filled like a lake with ice. Accumulation and ablation observations will be made at selected points and on one of the largest glaciers on the mountain, the Penck. It is hoped to obtain a temperature profile on the glacier down to 20 feet, but this project may be frustrated by the extreme toughness that characterises Kilimanjaro ice. It is hoped to map the "snouts" and ice edges on the mountain's flanks as well as the masses in the caldera.

The purpose of the meteorological work is to provide data for the interpretation of the accumulation-ablation balance studies in the glaciological programme. Self-recording met-stations will be set up at four regular stages from 9500 feet on the mountain to give a picture of high-altitude weather of interest to IGY meteorologists.

The geophysical work is expected to include the observation of magnetic declination and of terrestrial refraction at high altitudes; some work on palaeomagnetism; the rough analysis of the volcanic gases escaping from the mountain; and the exposure of nuclear-emulsion plates at high points for the benefit of the cosmic-ray work being done by Dr Ross of Edinburgh University.

"Hams" Welcomed

The last CSAGI meeting recommended that the existing international restrictions on the activities of amateur radio stations should be relaxed. It was pointed out that these stations could profitably be included in IGY work by transmitting data, and especially in the case of very isolated observing-stations. National committees were to take the matter up with their respective governments, and at the international level CSAGI forwarded a resolution to the International Radio Consultative Council.

Pinning Down Gough Island

The successful Cambridge scientific and surveying expedition to isolated Gough Island in the South Atlantic last season, is relevant to IGY activities for two main reasons. It established the island's position 1·3 miles farther North and East of that previously given, and filled in many of the other gaps in the knowledge of the island's geography. The regular meteorological patrol maintained by the expedition proved of such value that the Weather Bureau of South Africa was given permission to continue the station when the Expedition was relieved, and intends to operate this throughout the IGY.

The island, eight miles long and three miles wide, lies 1500 miles from South Africa and 250 from Tristan da Cunha, the nearest land. The Expedition gives Gough's position as 40°19′ S. 9°54′ W. Gough has never been properly speaking an inhabited island, and the last British explorers to call were from the *Quest* on Shackleton's last expedition, in 1922. Expedition members were inclined to endorse the opinion of Cdr Wild of the *Quest* that "this is an island on which a shipwrecked mariner could live without undue discomfort". Though classified as "sub-Antarctic" the island's climate proved considerably less harsh than this term suggests. There was no direct evidence that it had ever been covered by an ice-cap.

Geological specimens from Gough have still to be studied in the laboratory. Nevertheless the Expedition were able to confirm that the island's existence was due to the result of volcanic action in the Tertiary period. Specimens are being dated by radioactive methods, and a number of orientated rocks were collected in order to determine their palaeomagnetic alignment.

The 1955–6 Expedition to Gough Island promises to be one of the best-documented expeditions on record. Newspaper articles and broadcasts were made during its course. Since its return the editing of a 16-mm. colour film has been completed, and a book by Dr Martin Holdgate, the expedition's joint leader and senior scientist, is to appear in the summer.

Except for the cameraman and meteorologist, all nine members of the expedition were under twenty-five. Six of the nine-man party were from Cambridge. The meteorologist was lent by the South African Weather Bureau. The leader and surveyor, John Heaney, had accompanied Duncan Carse on the South Georgia Survey of 1951–2. The choice of Gough Island rather than an Arctic location was suggested by the Scott Polar Research Institute.

After his visit to the Falkland Islands Dependencies in January, the Duke of Edinburgh, who has throughout been interested in the Gough Island Expedition, paid a brief visit to the island.

Unique Ice Plateau in the Andes

Last summer an English climber and chemist, John Jewell, led an expedition to the Peruvian Andes, in the course of which he spent several weeks investigating the little known Quenamari "ice plateau" in the Vilacanota Cordillera which lies close to the Equator. As far as is known the "plateau" has never been visited before, but two years ago Dr G. H. Francis of the Natural History Museum saw the plateau in the distance while engaged in geological investigations in the Cordillera de Caravaya, and he suggested the investigation. The Swiss climber, H. R. Katz, was also impressed by the plateau which he saw from a distance of twenty miles some years ago. A reference by Prof. J. A. Douglas of Oxford, who crossed this part of the Eastern Andes in 1929, is thought to be the first mention of it in the geological literature.

Nowhere else in the Tropics is an ice-cap known to exist away from peaks or ridges which act as collecting points for the moisture which "feeds" the ice-mass. In the Quenamari plateau the ice, which covers an area of about thirty-six square miles, appears stranded in flat country unconnected with sources of fresh ice. How the ice-cap maintains its existence is a mystery. It is thought to be the remnant of extensive glaciation that once covered the Central Andes. The position of the "plateau" is 14° S. 71° W and it is between 18,000 and 19,000 feet high.

Mr Jewell succeeded in reaching the plateau, which stands several hundred feet above the surrounding country and terminates all round in precipitous ice-cliffs. Gigantic *séracs* fringe the plateau, which is highly crevassed. It extends for about twelve miles and varies from two to three miles across.

There was no glaciologist with the expedition, but a good photographic record of the area was made. Part of it was surveyed, and a number of hand-specimens of volcanic rock were collected from the foot of the ice-cliffs for study by the Natural History Museum. A meteorological record was kept. There was some evidence that the Quenamari ice, like that elsewhere, has been receding in recent years. Relatively little is known about residual ice masses in the Tropics, because they are not numerous, and are in extremely inaccessible areas. One of the aims of the IGY glaciological programme is to determine whether all the world's ice is in retreat, and if so if this is at a uniform rate and how long it has been going on. Until these questions are answered (and that depends upon adequate exploration and study of the areas) there can be no sound basis for an overall explanation of current ice movement. Mr Jewell (and others) think the Quenamari ice deserves an expedition to itself. Could this perhaps be arranged during the IGY?

LETTERS TO THE EDITOR

Atomic Explosions and the Weather

Sir:

I am not aware of the grounds on which Mr Geoffrey Bell asserts that "existing evidence" now suggests that atomic explosions could affect weather. His views are not shared by professional meteorologists. But my purpose in writing this letter is not to repeat familiar arguments or to reopen a stale controversy, but to point out that by omitting certain phrases in his quotations from my *Nature* article, Mr Bell has given a misleading impression of the strength of the arguments against his views.

Mr Bell concentrates attention on the electrical effects of an atomic explosion on a cloud of water drops, and quotes from my article part of a sentence in which I said it had not proved possible to compute a likely value for the electric charges on such drops. But he left out the words "several days or weeks after the explosion". I was concerned, not with local effects, but with global changes in weather. Nor does he mention my statement that even in thunderclouds, the charges on the drops have virtually no influence on their rate of growth, and finally, in discussing both my conclusions and those of Dr Mason, he omits entirely the essential fact, which we both emphasised, that the mechanism of such enhanced growth requires the water-vapour in the atmosphere to be supersaturated far beyond any value yet observed. All these factors are relevant, and must be considered quantitatively, before any belief in abnormal condensation or drop-growth processes caused by electrical influences can be seriously entertained.

My article dealt with the problem from many aspects and was therefore very condensed. Those who would like to see the details of the physics involved will find the calculations in an article by Dr A. C. Best, in the *Meteorological Magazine*, 84, 201–204 (July 1955). This should convince anyone that it is exceedingly unlikely, if not impossible, that there was any causal relation between the wet summer of 1954 and the Pacific explosions, at least as far as condensation processes are concerned.

GRAHAM SUTTON

Meteorological Office, Air Ministry, London.

Sir:

If omission of what seemed less essential parts of Sir Graham Sutton's article led to serious misrepresentation, I must apologise. One of my own sentences was, regrettably, somewhat ambiguous: I did not intend to say that existing evidence suggested atomic explosions *did* affect the weather, but that they could do so. On the other hand, I do not quite see how my letter suggested a concern only with local, rather than global, effects.

Dr Best's theoretical appraisal of the effect of electric charge on water droplet formation, published soon after Sir Graham Sutton's article, does, of course, settle some points of doubt. Its author's necessary assumptions appear reasonable, and Sir Graham Sutton's letter helps put the matter in balance. His last sentence is especially to the point. The caution of its phrasing is not at all reflected, I submit, in the statement to which I originally drew your attention. ("An investigation had shown that atomic explosions could not affect the weather.") Moreover, one would have thought that those responsible for nuclear explosion tests after World War II would have *immediately* checked all the possible side-effects of their devices; in fact, there seems to have been no detailed examination of this matter until 1955.

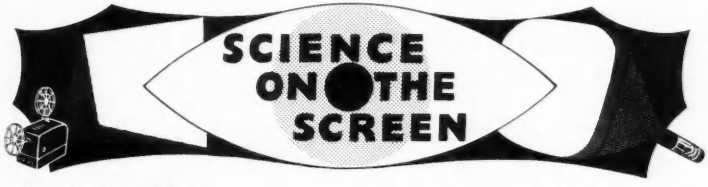
At least outside the pale of controversy is what Sir Graham Sutton calls "the wet summer of 1954". The period saw disastrous floods in Australia,* China, and India, with drought and all-time record high temperatures in central U.S.A.† But in any case may not subtler processes be more important than such gross effects as excessive rainfall or drought? One would welcome the assurance that increased ionisation in the atmosphere cannot influence the behaviour of haze, nor the formation of high-level (ice-particle) cloud. Significant changes in amounts of either, with evident influence on solar radiation, must affect the world's weather and, presumably, if prolonged, its climate.

As it is planned to shower clouds of ions into the world's atmosphere from Christmas Island during 1957, there may then be a good opportunity to investigate the matter more closely. Perhaps the leading meteorologists of different areas of the world might be invited to collaborate.

GEOFFREY BELL

* *Australian Newsletter*, March 3, 1955. ("The floods are the greatest disaster Australia has ever known. They exceed in extent any other national disaster. . . .")

† *Weather*, vol. X, No. 3: p. 71, (March 1955.)



A New Flat Picture Tube

Speaking to the Television Society on October 25 on the design of his new flat television tube, Dr Denis Gabor, F.R.S., said that the idea came to him four years ago and that it had been worked out with the aid of the National Research Development Corpn in the Electronics Laboratory at Imperial College.

By 1952 it had appeared certain that tube manufacturers would soon be faced with the problem of a reliable and inexpensive colour television tube and the flat tube seemed to be the solution of the colour tube problem. The tube itself has the shape of a rectangular glass box having a total depth of only 4½ inches for a 21-inch screen. It is divided into two halves by a metal tray which carries the whole electron optical system and which also acts as a magnetic screen for the beam. By an ingenious system of electron lenses the beam is curved to run parallel with the glass faces of the tube and is finally deflected towards the screen by a series of conductors which run parallel to the screen itself.

The flat tube can be made safer than the conventional television tube because the glass is specially toughened, as in car windscreens. These tubes might therefore dispense with the safety screen in front. They would not be damaged by accidental scratching.

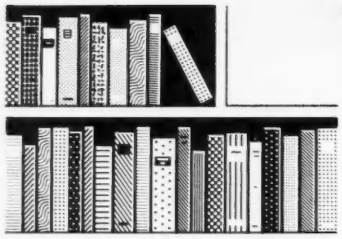
The tube has several novel features of construction, including the use of silicones as insulation in the electrode system. This, as far as is known, is the first time that they have been used in a sealed-off vacuum device. For colour television, the separate phosphors are deposited on the glass face through a shadow mask by a method which will prove far more economical than the present method of depositing a colour screen by printing a phosphor in register.

Dr Gabor stressed that the tube was still in the development stage.

Great Adventures Televised

The story of man's greatest adventures, from prehistoric caves to the frontiers of space, is being told in a series of United States television programmes entitled "Odyssey". They are produced by the Columbia Broadcasting System. Viewers will make an electronic journey covering thousands of years and travelling to all parts of the globe. They will share the tribulations of a Roman legionary in A.D. 100, and will learn of the exploits of the 12th-century Japanese warrior Yoshitsune, personifying the Samurai paradox of gracefulness with strength. Scott's Antarctic expedition will be included in the programme. An important feature of the "Odyssey" will be the contribution made by museums of art, history, science, and industry, both in the United States and other countries.

THE BOOKSHELF



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Held in Geneva, August 1955. United Nations Publication.

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The entire series of volumes dealing with the papers read at the Geneva Conference on the Peaceful Uses of Atomic Energy has now been published in sixteen large and well produced volumes. The papers cover every aspect of a technology which has wide ramifications, and has grown into a major industry in little more than a decade. It appears likely that the overall view presented will indicate the course of future development for a long period, unless a practicable thermonuclear power process is developed.

Vol. 1 opens with several papers surveying world requirements for power now and in the future, the conclusion being reached that existing energy sources will be quite inadequate to meet the demand anticipated in A.D. 2000, and that the large-scale development of nuclear energy in the interval will become imperative for most countries. Then follows a series of papers assessing the individual outlook for future nuclear power requirements for thirty-six countries, and the industrial and economic implications. Four papers discuss the training of the large technical staffs which will be needed in the future.

Vol. 2 contains twenty miscellaneous papers on nuclear physics topics, including neutron scattering and reaction cross sections, and twelve papers on theoretical and experimental studies of the fission process. The remainder of the volume contains reports on the varieties of research reactors which may be built, and the research programmes for which they may be used, and individual accounts of the design and operating characteristics of reactors, including the British graphite-natural uranium reactor Bepo, and the heavy water-enriched uranium E443 with an anticipated thermal neutron flux of 10^{14} /cm.^{2}/sec., the Russian reactors, one with uranium and heavy water, and three with light water and enriched uranium, the Norwegian Jeep with heavy water and uranium, the proposed Swiss reactor, the French heavy water-uranium Saclay reactor, and several United States reactors, including the group of Materials Testing Reactors using enriched uranium and light water and attaining neutron fluxes up to 4×10^{14} /cm.^{2}/sec., the Oak Ridge graphite-uranium and Low Intensity Testing reactors, the Brookhaven graphite-uranium reactor, and small swimming-pool and water-boiler reactors suitable for smaller research institutes.

Vol. 3 discusses the economic aspects of nuclear fuel cycles, and the possibilities of breeding fissile materials, and a variety of designs for power reactors, including graphite-moderated reactors cooled with gas, water, or liquid sodium, homogeneous and heterogeneous pressurised water reactors, fast sodium-cooled breeder reactors, and a uranium-liquid bismuth system. The contributing countries were Britain, Russia, the United States, Norway, Holland, and France.

Vol. 4 contains a group of papers dealing with the measurement of neutron interaction cross sections using mechanical velocity selectors, pulsed source time-of-flight, crystal spectrometer, pile oscillator, mass spectrometric and other methods, and an important series of papers on delayed fission neutrons, cross-sections for fissionable nuclei, and the number of neutrons per fission. The values for the cross sections, hitherto classified, obtained separately in France, Britain, Russia, and the United States show, in almost all cases, astonishingly good agreement.

Vol. 5 contains papers on experimental measurements of neutron diffusion in moderators such as water, graphite, beryllium and beryllium oxide, on resonance absorption, and on zero energy, exponential and critical assembly experiments with both moderated and fast reactors. There are also 21 papers dealing with a variety of aspects of reactor theory.

Vol. 6, which runs to over 800 pages, is mostly concerned with a series of 100 papers, dealing with the occurrence of uranium and thorium, submitted by twenty-one nations. The information from the United States is very detailed and extensive. There is a noticeable absence of information on Russian resources. The remainder of the volume deals with instruments and methods used for prospecting.

Vol. 7 deals with a variety of chemical aspects of the subject, including studies of the fission process, radio-chemical laboratory facilities, the processing of gross fission products, a large number of papers on the chemistry of individual fission products, the transuranic elements and polonium, and on the effects of irradiation on reactor materials, liquids and solids.

Vol. 8 deals with the treatment of uranium and thorium ores and ore concentrates, including a variety of leaching processes, and precipitation, ion exchange and solvent extraction methods for the recovery of uranium. The remainder of the volume contains papers on the production of uranium and thorium metals, analytical methods used in raw material production, and the production and analysis of heavy water, graphite, zirconium, beryllium and beryllium oxide.

Vol. 9 contains a variety of papers on the disposal of fission product waste by storage or discharge into the ground or sea, the processing and utilisation of fission products, the metallurgy of uranium and thorium, the fabrication of fuel elements and their processing after irradiation in order to extract plutonium or ^{233}U. Seventeen papers discuss various aspects of the use of liquid metals as heat transfer agents in reactors.

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McGraw-Hill Publishing Company

The Bull Cup from Enkomi, c. 1400 B.C. (1) as excavated, the silver, inlaid with gold and miello, completely covered with corrosion products, and (2) after treatment and restoration. The photographs are from the book by Prof. Plenderleith reviewed on this page, and are reproduced by courtesy of the British Museum.

Vols. 10, 12, and 15 deal mainly with the innumerable applications of radioisotopes and radiation in medicine, in agriculture, physiology and biochemistry, and in industry. Among the subjects discussed, only a few can be mentioned in order to illustrate the vast range covered. They include the destruction of tumours by radiation, studies of thyroid function with radioiodine, radiation genetics and plant breeding, studies of plant nutrition and fertilisers, plant and animal metabolism, immunology, radioactivation analysis, thickness gauging, radiography, and the radiation sterilisation of foods and medical supplies.

Vol. 13 deals with legal and administrative problems connected with the use of atomic energy and the distribution of radioisotopes, reactor safety and location, the maximum permissible exposure to radiation, health hazards in uranium mining, reactor operation and chemical processing, and ecological problems raised by the escape of fission products into the air or sea.

Vol. 14 contains miscellaneous papers on the large-scale supply of radioisotopes, the preparation of certain multicurie sources, and on instruments for scintillation counting, pulse analysis and beta- and gamma-ray and neutron dosimetry.

F. D. S. BUTEMENT

The Conservation of Antiquities and Works of Art

By H. J. Plenderleith. (*London, Oxford University Press, 1956, 374+ xvi pp., 63s.*)

Present-day society takes a great interest in the problems of conserving precious materials of all kinds. With this interest is linked an awakening of sensibility, both professional and amateur, towards the progress of archaeology and the well-being of its "finds". For all these reasons Prof. Plenderleith's book was assured of a wide reception even while—like the ark—it was "a-preparing": now that it has materialised, everybody engaged in conservation should be anxious to obtain a copy. And not only they, for quite a number of people will benefit who desire to experiment themselves, as indeed within limits can be done with these pages as a guide. Here, in fact, lies the strength of this volume: it is written with all the equipment and experience of a celebrated laboratory behind it, yet in language comprehensible to the layman. And that is because the author knows exactly what should be done and what practical difficulties always present themselves in doing it. It is so easy to set out a simple set of rules, so much harder to anticipate the pitfalls.

The structure of Prof. Plenderleith's book is in itself significant; he begins by discussing the influence of environment, branching out from there to deal with organic materials (Part I), metals (Part II), and silicones and related materials (Part III). Then, having, so to say, disposed of his "patients", he returns to the bench with a valuable set of appendices. These deal with such matters as the strength of solutions, dangerous chemicals, pH (so vital for any rational concept of the nature of acids and alkalis), silica gel, electrolytic reduction, and so on. From all of which it is clear how idle it is to admire the transformation—as depicted in a number of excellent illustrations—effected in the treatment and repair of a wide range of museum objects, without realising the degree of skill and specialist knowledge behind these triumphs of conservation. No less should one appreciate the caution and responsibility displayed in each approach.

In the reviewer's opinion it seems likely that Prof. Plenderleith will be found to have performed another service to his generation, and that is to inculcate a kind of subconscious feeling for antiquities as things *sui generis* which the scientist may indeed help to preserve, but which transcend a rigidly experimental philosophy, calling out, as it were, an awareness of history and of character at once unique and irreplaceable. The illustrations reproduced are examples of the skill expended in bringing back to life man's early accomplishments.

To return to the point from which we started. Fig. 3, a comprehensive statement (in the form of a family tree) of the causes of damage to museum objects, collects together vividly all the ills to which they are prone. Given the will, and the means, to control these, the responsible authorities can go ahead with a wide range of specific treatments as recommended in the body of the book. Only someone who has gripped these problems at first hand, like Prof. Plenderleith, and who is sensible of their implications, could have written a classic such as this.

The reader will be grateful to the Oxford University Press for producing a volume which is agreeable to handle and pleasing to the eye.

F. I. G. RAWLINS

Breads White and Brown

By R. A. McCance and E. M. Widdowson (*London, Pitman Medical Publishing Co., Ltd, xi+174 pp., 30s.*)

What we call science today is what was once known as natural philosophy. It is a particular way of finding out truth and is based on observation and experiment. Progress in science depends on someone thinking about facts and then elaborating a theory, or hypothesis, or, if the interpretation of the facts seems sufficiently clear, a "natural law". If then further experiments give results in conformity with the hypothesis, the chances are that the hypothesis is correct. If the experimental results do not

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E. OWER, B.Sc., and J. L. NAYLER, M.A. [30*s.*]

This book explains to the layman, with a minimum of technicality, the human and mechanical problems of high speed and supersonic flight. It is very fully illustrated in line and half-tone.

fit the preconceived theory, then there must be something wrong with the theory. Scientific thinking is most effective when it is restricted to a strictly objective topic. It works very well, for example, for the elucidation of the chemical structure of an unknown substance, say vitamin B_{12}. When the analyst has finally decided what the structure is, he can carry out a synthesis of what he believes he has got and thus verify by experiment the accuracy of his deductions. But without experimental verification his conclusions can claim no more validity than the opinions of anyone else.

The book on white and brown bread by Prof. McCance and Dr Widdowson illuminates two important points about modern scientists. The first is that when their personal prejudices and emotions are involved they may become as unscientific and fallable as any layman. The second point is a more disagreeable one. It is that a chemist, biochemist, nutritionist, or physiologist cannot claim to be a *professional* scientist so long as he can be hired to support any interest his employer wishes to promote.

"Breads White and Brown" is a work of scholarship that is delightful to read. It is excellently documented. Side by side in the list of references we find "Venner, T. (1622)"; "Vickery, K. F. (1936)"; "Virgil — (c. 30 B.C.)"; and "Voigt, M. (1876)". The book is designed as a narrative. First is an account of the types of bread available in classical Greece and Rome, the gradual replacement of barley by wheat and the high esteem in which fine white loaves were held. Yet even in 200 B.C. there were people like Cato to be found hankering for the good old days when everyone was healthy and happy eating barley cakes and wholemeal bread.

Between the years A.D. 1200 and 1700 in England, to have white bread made from wheat constantly in the house indicated wealth and substance. On the other hand, the servants, the labourers, and the poor ate brown wheaten bread if they could afford it, but mostly they ate bread made from various combinations of wheat, rye, barley, or beans. McCance and Widdowson point out that it was in this period, as early as the second half of the 14th century in fact, that the millers, who ground corn brought to them for a fixed fee, first acquired the bad press that they have never yet quite succeeded in throwing off. The miller of Dee who, in the 13th century, sang "I care for nobody, no, not I—If nobody cares for me", and the trade paper *Milling*, which outfaced the arguments of 20th-century nutritionists with intemperate abuse and invective, show a strange consistency across the years.

The authors' narrative continues into the 18th century and on to 1820 with the demand for white bread for the growing towns steadily increasing. To improve the whiteness of their flour, bakers began to add alum, chalk, or ammonium carbonate. Even after these were prohibited in 1758 and the subsequent exposures of Accum in 1820, the practice of adding chemicals continued to grow. People wanted a white loaf and they wanted a cheap loaf. By acting as they did, write McCance and Widdowson, bakers probably satisfied most of their customers without doing them much harm, but they also brought upon themselves considerable suspicion and abuse. Later on, steel rollers and silk "bolting" cloths were introduced in 1870 to deal more effectively with the "hard" wheat from the United States. The use of bleaching agents and "improvers" began at the turn of the 20th century, in spite of the long-established Bread Acts of 1822 and 1836 forbidding the adulteration of flour.

And so we come to the present age of "science". Sylvester Graham became the first devout apostle of wholemeal bread. Dr T. R. Allinson followed, coupling his faith with teetotalism and anti-vaccination fervour as well. By 1911 the discovery of vitamins came to provide ammunition for both sides in the debate on the respective merits of brown and white bread that continues to this day. For those of us who are uncommitted in this extraordinary controversy, the part of the book dealing with the modern debate is interesting from a number of points of view. It reviews in general terms the technical considerations involved—the analysis of different types of bread and their relation to nutrition—but it also describes how scientists of considerable eminence took up diametrically opposed opinions about the implications of what they conceived to be the facts.

McCance and Widdowson's narrative moves at a fast pace. The authors steer us skilfully through the confusing maze of argument and incident: the American scene, the Canadian solution, the addition of vitamins and minerals to white flour, the shifting grounds taken up by protagonists, the accusations of bad faith, the claims and counterclaims of widespread malnutrition whether visible or invisible, in weanling rats, in puppies or in black-beetles. There is something just a little Kiplingesque about the story. One turns the pages eagerly to find out from these sapient authors what the *right* answer to the problem really was. But, of course, there is no "right" answer.

"The whole problem of proper nutrition is so frequently bedevilled by ignorance, prejudice, and fanaticism that it behoves every writer on the subject of food to exercise restraint, caution, and rigid scientific integrity." McCance and Widdowson, who head their last chapter with this quotation from Prof. Garry, have done more than this. At the point where argument had come to stalemate they pursued the matter in the only useful way open to a scientist. They designed and carried out an experiment to get more facts. They fed groups of children on white bread, on brown bread, and on bread with added vitamins and watched them grow—and there was not a penny to choose between any of them!

MAGNUS PYKE

Arthur Stanley Eddington

By A. Vibert Douglas (*Edinburgh, Thomas Nelson and Sons Ltd., 1956, 207 pp.+xiv and fifteen plates, 25s.*)

It is perhaps a vain hope to expect that every great leader of scientific thought should have so excellent a biography prepared as Miss Douglas has done for the late Sir Arthur Eddington. It is not only that Miss Douglas writes with a rare sympathy for her subject—as we might expect one of Eddington's students to do—but also that she draws with masterly strokes Eddington's character and genius, and reviews the work of this great astronomer in such a way as to give us good reason to appreciate why he was one of whom it is said "his achievements are among the greatest which his time can show".

Miss Douglas begins by sketching Eddington's early years, emphasises his interest in astronomy and mathematics and his scholastic abilities, which resulted not only in a first-class physics degree at Manchester, but also in Eddington being the first second-year man at Cambridge ever to become a Senior Wrangler. His eight years as a Chief Assistant at Greenwich, so often overlooked, is well dealt with; the thorough familiarity with practical observing which Eddington obtained and which was to stand him in such good stead later, is ably shown.

It is, of course, Eddington's theoretical work on the internal constitution of the stars, on relativity, and on the wider aspects of cosmology, for which he is remembered now. Sometimes forgotten are his battles with Sir James Jeans over the mechanism of stellar radiation, which Miss Douglas brings graphically before us and from which she leads up to Eddington's brilliant and almost intuitive idea that sub-atomic processes were the means of energy generation. That Miss Douglas is herself an astronomer is of vital importance here, for she explains clearly, and yet with a sense of quite proper excitement, the whole picture of Eddington's ideas and arguments.

The work and advocacy which Eddington poured forth on relativity—and which earned him the gratitude of Einstein, who remarked that he would so much like to talk to him that . . . "for this alone it would be profitable for me to learn the English language"—is given in some detail, while Eddington's popular lectures and his important books all receive due mention. Miss Douglas's chapter on his last work, *Fundamental Theory*, gives a good analysis of Eddington's aims and philosophical approach to his theory in which he suggested reasons for the significance of certain numerical constants which appear in nature. Throughout

the discussion of this most interesting section of his work the writing clearly shows up Eddington's boldness of thought and his clear understanding of the nature of scientific laws.

Eddington had a whimsical side to his nature which peeped out from time to time. The quotations with which he prefaced the chapters of his books show this very well. Miss Douglas has followed a similar course in her biography, and this is shown up best in her quotation at the head of the chapter on Fundamental Theory—a musical stave giving a quotation from Schubert's "Unfinished" Symphony! Eddington's religious convictions as a member of the Society of Friends are not forgotten and are sympathetically dealt with, and all in all this is a first-class book. It is well printed, contains a bibliography of Eddington's published work, and a number of plates all aptly chosen and always relevant. It can be strongly recommended to all interested in modern astronomy, the universe, and relativity, as well also to those who would like to know something of the life, outlook, and work of one of the scientific giants of the 20th century. C. A. RONAN

Mada (Science)

A new Hebrew scientific quarterly. Price $1.50.

The industrious Israeli scientists have produced a new scientific quarterly journal, *Mada* (*Science*), in Hebrew. In aims and presentations it resembles DISCOVERY, on which it may have been modelled, though the choice of topics is naturally influenced by problems facing Israeli scientists. The contributions to the first two numbers are all of high quality, and one hopes that this standard will be maintained.

A typical example of the kind of article in the journal is one by Dr Bentor on minerals in Israel. This gives a historical survey of the exploitation of minerals in the country, an account of recent research, and an estimate, together with a geological map, of mineral resources in the country. There are articles of similar general interest on prospecting for oil, crystal growth, the harnessing of solar energy (with a description of a new solar "trap"), tissue culture, bilharzia, bacteriophages, and papers on the history of science and medicine. An article of rather a different kind, by Dr Bar Hillel, deals with the problems of mechanical translation, a subject on which he worked at the Massachusetts Institute of Technology.

This range of topics will doubtless be extended to cover the entire field of natural science and technology. It may, however, be to some extent limited by the availability of scientific specialists in Israel and by their capacity for conveying highly technical material in language intelligible to a non-technical public. One would like to see embodied in the journal full abstracts of the articles in English in order to make them accessible to those who have no knowledge of modern Hebrew. Apart from the original articles themselves, there is an illustrated section on the flora and fauna of Israel, notes on current scientific events, activities and personalities in the country, and book reviews.

The editors (Drs Hestrin and Katchalski) and their advisory board are to be congratulated on their initial achievement. Let us hope that this newcomer to the ranks of scientific periodicals will be blessed with a long and vigorous life. Indeed, its future is well assured by the fact that its sponsoring bodies wisely include all the important centres of science and technology in Israel: the National Research Council, the Ministry of Education, the Hebrew University at Jerusalem, the Technion at Haifa, the Weizmann Institute, and the Bialik Institute. JOHN COHEN

Modern Methods of Microscopy

Edited by A. E. J. Vickers (*London, Butterworth's Scientific Publications, 1956, 114 pp., 15s.*)

This book consists of a series of papers reprinted from *Research*. There are thirteen contributions, all by acknowledged authorities, covering the field of fluorescent and polarising microscopy, the reflecting microscope, phase contrast and interference microscopy, the flying spot microscope, electron microscopy and x-ray microscopy.

The book is excellently produced and well illustrated, and each paper concludes with a list of references so that the reader is presented with a list of the most important papers on microscopy which have appeared during recent years.

The book can be thoroughly recommended to all who wish to keep abreast with modern developments of the microscope and with microscopical methods.
R. MCV. WESTON

Language and the Pursuit of Truth

John Wilson (*London, Cambridge University Press, 1956, vi+105 pp., 8s. 6d.*)

This is a sensible exposition of some of the ways in which language may be "weighted" on the side of prejudice rather than of truth. However, the author begins his preface with the words, "This book is an attempt to do something new: to present semantics, which is the study of linguistic communication, to the general public." Linguistic communication has been going on for quite a long time; it has been studied almost as long; and quite a number of people, from before Socrates to A. P. Herbert and after, have presented the results of their studies to the general public. The only new thing, therefore, seems to be the word "semantics", and one does not create a new science by inventing a new word. I. NICHOLSON

Balloons

By C. H. Gibbs-Smith (*London, The Ariel Press, 1956, xv+12 coloured plates, 25s.*)

Only a few weeks ago, the U.S. Navy announced that one of its balloons had reached the record altitude of 76,000 feet. It is therefore pleasant to be reminded that it was the balloon which gave man his first flight, and that the gaily coloured Montgolfières and Charlières attracted the first aeronauts.

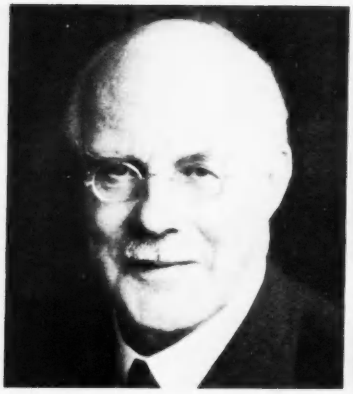
The present collection of colour prints has been made only from the point of view of pictorial beauty, although they are, of course, of historical and aeronautical interest. Superbly printed in Germany, they are a pleasure to behold, although they offer little to a scientist searching for information. One might perhaps wonder if the present design of space-ships will have the same ridiculous effect on our future grandchildren as the floating phantasy of "La Minerve" —a grandiose aerostatic creature designed for aerial voyages of discovery in 1803—has on us. A. R. MICHAELIS

Brief Notes

"Scientific Research in British Universities 1955–6 (H.M.S.O., price £1 1*s.* 0*d.* net) is a useful volume providing notes on scientific research in progress in British universities and university colleges. The names are listed of permanent members of the staffs actively engaged in supervising research. The entries are arranged in alphabetical order of university, each institution being numbered to facilitate indexing.

The 58th edition of "Scientific and Learned Societies of Great Britain" provides a wealth of important information to those scientists who are anxious to know about the organisation of science in this country. Full details are given of the history of each society, its objects, meetings, publications, membership, and fees. If a society has a library, the number of books and periodicals taken is listed. This should prove an interesting source book for statisticians, who might care to plot the membership of learned societies against age of the society. The Publications Division of the British Council is responsible for the compilation, and the book is published by Allen and Unwin at 35*s.*

The *Financial Times* survey, "Metals in Industry", was published at the beginning of December. It contains a survey of the technical and commercial aspects of all the common metals. Particularly interesting is a note on beryllium in atomic reactors; and other rare metals, like zirconium, germanium, and selenium, are also dealt with. This excellent publication would gain by having a subject index, so that techniques of metal refining could be cross-checked. One also misses the name of the editor responsible for producing the monograph.



SIR HAROLD HARTLEY, G.C.V.O., F.R.S.

SIR JOHN COCKCROFT, O.M., F.R.S.

DAME JANET VAUGHAN, D.B.E.

FAR AND NEAR

New Year Honours

Scientists will have read with great pleasure on New Year's Day that the Order of Merit in this year's Honours List was bestowed on Sir John Cockcroft. Through this singular distinction the whole of British Atomic Energy Research and Technology has been honoured as it justly deserves. Sir Christopher Hinton, Managing Director of the Industrial Group of the AEA, has similarly been singled out with a K.B.E., and W. L. Owen, the Director of Engineering in Sir Christopher's Group, has been created a Knight Bachelor. The British Empire Medal goes to E. G. Gale and P. Legge, both of whom worked on the construction of the Calder Hall Reactor. We miss the name of Mr H. G. Davey, the works manager, from this list. His fine work should surely have been recognised.

As we have shown regularly in the columns of DISCOVERY, the organisation before the official opening of the International Geophysical Year has meant a very great deal of strenuous work behind the scenes. This is recognised in the New Year Honours List by a Knighthood to James Mann Wordie, Chairman of the British Planning Committee. Sir James was Geologist and Chief of the Scientific Staff of Shackleton's Antarctic Expedition from 1914 to 1917, and many later expeditions.

That a previous Editor of DISCOVERY has been honoured with a Knighthood must please all readers. Sir Charles Snow is, of course, well known as a scientist and writer, and more recently as the Scientific Adviser and one of the Commissioners of the Civil Service Commission. He edited DISCOVERY from April 1938 to March 1940, when DISCOVERY was being published by the Cambridge University Press.

The Knighthood conferred on David Stirling Anderson is a well-earned recognition of his work on technical education over many years, which has now culminated in his Directorship of the Royal Technical College, Glasgow.

Knighthoods have also been conferred on George Lindor Brown, Jodrell Professor of Physiology in the University College, London, and on George Robert Edwards, Managing Director of Vickers-Armstrongs Ltd., who has for many years carried out research and design on Britain's aircraft.

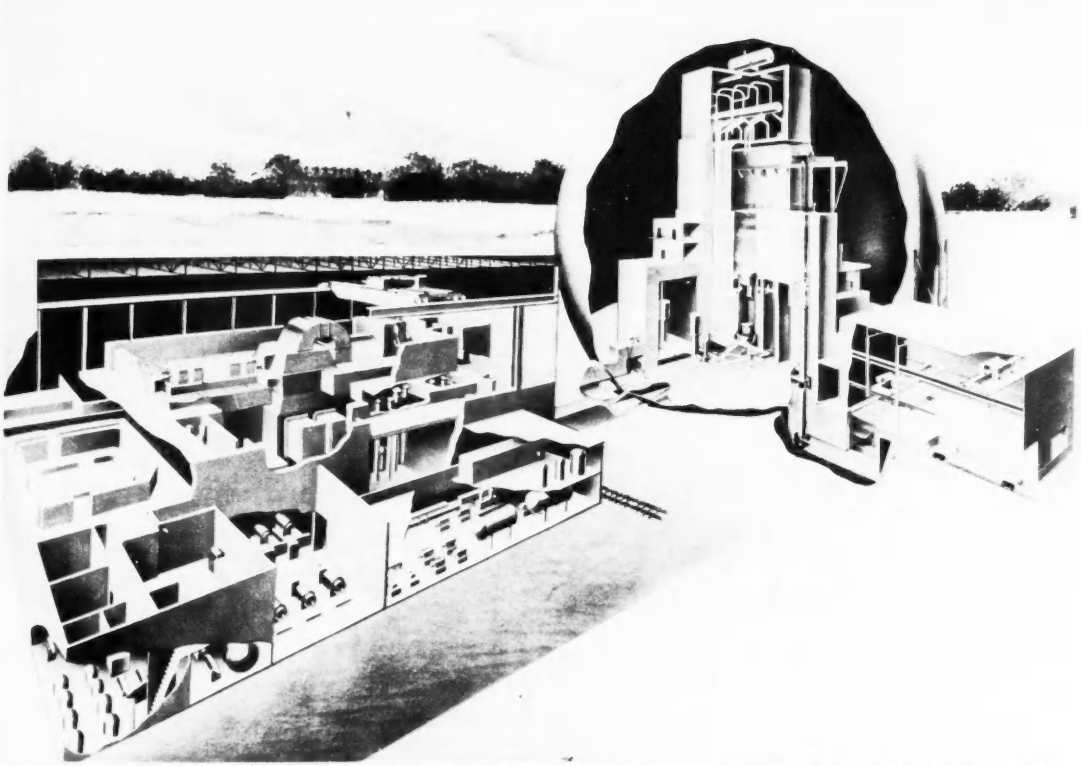
Among the honours conferred on distinguished women is the D.B.E. to Janet Vaughan, Principal of Somerville College, Oxford, a physiologist and medical research worker of international repute. Her contributions to research on blood diseases and in the blood transfusion services are well known, and she was the first scientist to be appointed Principal of a women's college in Oxford.

Australia's growing contribution to science is well reflected in the Honours List. One might single out L. H. Martin, Professor of Physics at Melbourne University, and M. L. Mitchell, Professor of Biochemistry and Deputy Vice-Chancellor at the University of Adelaide, who both receive Knighthoods; Prof. E. W. Titterton, a contributor to this Journal and Professor of Nuclear Physics at the Australian National University, Canberra, an atomic physicist of world-wide reputation, who receives the C.M.G.; and Dr P. L. Bazeley, Director of the Commonwealth Serum Laboratory, who receives a C.B.E.

Among the many other scientists in the Honours List at home, Sir Harold Hartley receives the G.C.V.O. He is, of course, well known for his work in chemistry and industrial research. Sir Alexander Carr-Saunders receives the K.B.E. And among those receiving the C.B.E. are: B. K. Blount, Deputy Secretary, DSIR; A. Barclay, Keeper of the Science Museum, where he is responsible for the departments of chemistry and photography and has spared no trouble in making the historical collection of equipment as comprehensive as possible; D. M. Campbell for development of speed boats; A. T. Green, Director of Research at the British Ceramic Research Association; O. W. Humphreys, Director GEC Research Laboratories; P. Lloyd, Deputy Director of Research and Development, National Gas Turbine Establishment; J. F. Loutit, Director of the Radiobiological Research Unit, Harwell; J. Martin, Managing Director, Martin-Baker Aircraft Company; Prof. W. V. Mayneord, Professor of Physics applied to Medicine at the University of London; R. H. Stoy, H.M. Astronomer, Royal Observatory, Cape of Good Hope.

Nuffield Foundation Awards

In 1951 the Nuffield Foundation initiated a scheme awarding bursaries for post-graduate training in biology and sociology. The biology awards are intended for graduates in physics, chemistry, mathematics, or engineering, and the sociology awards for graduates in the natural sciences and the humanities. The purpose is to attract into, and train for, these subjects a few graduates who already have the advantage of having followed other disciplines. The Foundation's offer of these scholarships and bursaries is being repeated this year. Candidates should normally be between ages 22 and 35 and resident in the United Kingdom.



Applications must be received by April 1, and details are obtainable from the Director of the Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1.

Nuclear Power in Illinois

The photograph at the top of this page shows the design of the Dresden nuclear power station being built by the General Electric Company, U.S.A. It is a 180,000-kilowatt boiling-water reactor plant. The nuclear reactor and its related components will be contained in a steel sphere 190 ft. in diameter. The turbine-generators building is at the left, and fuel-handling facilities at the right. Fissioning uranium will cause water in the reactor to boil and form steam, which will then drive the turbine generator to produce electric power. The Dresden station will be built on the Illinois waterway fifty miles south-west of Chicago.

Conference on Rheology

The British Society of Rheology is organising a conference on "Rheology of Elastomers" to be held at the Rubber Producers Research Association at Welwyn Garden City on May 30 and 31, 1957. Contributions are invited for this conference and intending speakers are asked to write first to the Hon. Secretary, 52 Tavistock Road, Edgware, Middlesex.

Anglo-Saxon Finds at Yeavering

Excavations at Yeavering, near Wooler, Northumberland, have yielded important discoveries relating to Anglo-Saxon times. They throw new light on life in the Dark Ages, covering a period from about A.D. 550, shortly after the coming of the first Anglo-Saxon invaders, to about A.D. 633 when King Edwin was defeated by Penda of Mercia and Cadwallon of North Wales.

The site was first revealed by aerial photography as rectangular dark patches in a field of oats. Mr Brian Hope-Taylor, who has been in charge of the operations, has unearthed foundations of a complex of buildings, including the hall of a royal palace, the first palace of the period to be discovered in Britain. This complex forms the "royal township" which the Venerable Bede recorded in the 8th century as having been established by King Edwin of Northumbria a century earlier. Here Paulinus, the missionary who converted Edwin to Christianity, preached to the people and baptised converts in the nearby River Glen.

The foundation of an amphitheatre, in the shape of a wedge out of a circle, is one of the most important finds.

Around a royal hall were set eleven smaller buildings, probably for nobles, though there is evidence that one may have been used by servants, and another was a temple. Near one end of the complex are the signs of a fortress of earthworks and parallel protective ditches, which may have dated from the coming of Anglo-Saxon invaders and hence before the building of the township in more settled times.

Italy's "Atom City"

Italy is to build an "Atom City" on the banks of Lake Maggiore. Four hundred acres of uncultivated land have been bought near the little town of Ispra by the Centre Italiano Studi ed Esperimenti. The first atomic pile at Ispra should start operation in 1958.

Computers for St Thomas and the Dead Sea Scrolls

Electronic machines of the IBM World Trade Corporation, represented in this country by IBM United Kingdom, have been used for indexing the writings of St Thomas Aquinas. The work which occupied ten men and electronic data processing machines for five years, might otherwise have taken fifty scholars forty years. Whole sentences are fed to the machines on punched cards: these are then transferred to magnetic tape, and the tape then reproduces individual word cards showing the location, context, and details of the word in question.

An IBM giant 705 computer will now be used for similar work on the controversial Dead Sea Scrolls. This work will be supervised by Prof. Millar Burrows, of Yale University, and the Italian scholar, Prof. Pietro Boccaccio, S.J., of the Biblical Institute of Rome.

The work on the writings of St Thomas is being supervised by Father Busa, of the Pontifical Faculty of Philosophy in Gallarate, near Milan. Father Busa said that the work, by saving thousands of hours, will not only be a major advance in literary and linguistic research, but will also aid industry and science.

"Calder Hall" For Japan

Japan will probably buy a Calder Hall type atomic power station from the U.K. if various points of detail raised by the Japanese mission of atomic scientists and engineers, who have visited U.K. atom power projects recently, are settled satisfactorily.

Points to be settled are understood to include recalculation of the cost of atomic power from such a reactor, taking Japanese rates of interest into account, the settlement of details concerning the repurchase by Britain of the by-product plutonium produced during the operation of the power station, and the problem of ensuring against earthquake damage to the station.

An inter-governmental agreement will have to be concluded between the U.K. and Japan. Problems of Japan's foreign currency balance will also have to be considered.

Remote Control Tractor

Australian farming moved into the age of automation on November 7, 1956, with the demonstration of a tractor operated by remote control. After nine months of research by an Australian tractor firm, it was put through its paces in the grounds of the Passionate Fathers' Roman Catholic Seminary at St Ives, near Sydney. A man seated at a push-button control board was able to turn the tractor, regulate its speed, and raise and lower the disc cutter behind it.

The tractor is little different in appearance from the manual kind, except for small hydraulic fittings at the side, a radio control box behind the driver's seat, and tall aerials. It is an experimental model and there are as yet no plans for its commercial production.

Atomic Energy Applied to Oil Industry

A comprehensive study, privately financed and conducted to develop widespread atomic energy applications in the oil industry, is now under way in the United States.

Esso Research and Engineering Company is financing the study, which will be carried out in the Columbus, Ohio, laboratories of Battelle Institute. The aim is to perfect ways of using nuclear radiation in petroleum refining and in the production of petrochemicals.

A "swimming-pool" type reactor will be used in the study; it will be a source of strong gamma and neutron radiation. Samples of oil materials and possibly miniature models of refining units will be placed in the pool and exposed to radiation. Esso Research anticipates that the Battelle reactor programme will confirm and extend the possibilities of irradiation processing in the petroleum industry.

The Chemical Basis of Life

The Third Programme is broadcasting a series of six talks on the Chemical Basis of Life, beginning on Friday, February 1, at 8 p.m., when Prof. E. Baldwin will speak on energy changes and chemistry cycles. The second talk, on Thursday, February 7, will be by Prof. W. T. Astbury on master plans of molecular biology. He will describe how the great multiplicity of varied and complex tissues are built up from a comparatively small number of units. Dr E. F. Gale and Prof. C. D. Darlington will conclude the series by giving the genetical point of view, dealing first with chromosomes, and then with genes and viruses.

Erratum

In the note on a new moth in southern England which appeared on p. 493 of the December issue, the magnification of the moth should have been 1:3, and of the pupa 1:5.

Continued on p. 87

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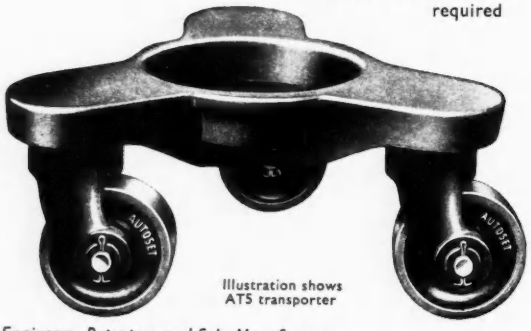

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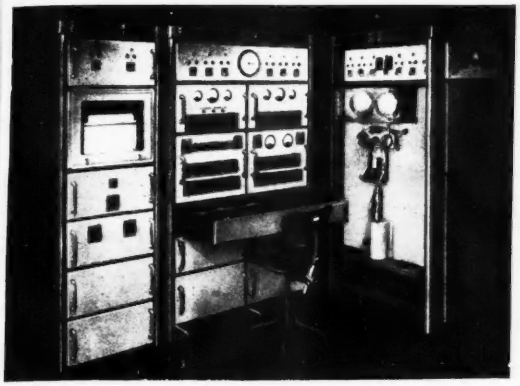

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117	0·56	0·16	0·47	3·2	**69·9**	14·0	2·7	2·9	5·7	0·44
118	0·22	<0·04	<0·04	0·25	0·93	**94·1**	2·95	1·36	0·08	0·10
119	0·33	0·11	<0·04	0·49	0·72	18·5	**71·7**	7·3	0·67	0·22
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The table illustrates the application of the MS2 to Isotope assay work. Samples of stannic chloride enriched by electro-magnetic separation, were analysed and compared with a normal sample. The figures in bold type are the final amounts of the particular isotopes in which the samples were enriched.

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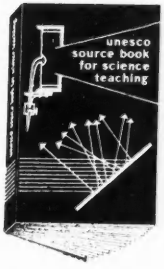

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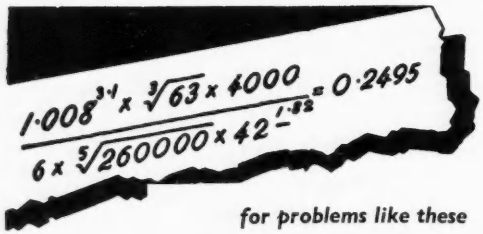

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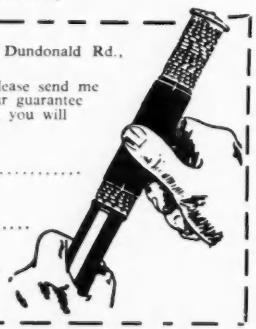

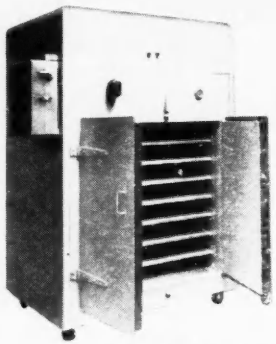

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FAR AND NEAR—continued

The Cologne Photokina

A visit to the biennial German Photokina in Cologne shows how the restriction of imports and the heavy duty and purchase tax on cameras and film in England has prevented the average Briton from becoming as aware of the possibilities of the camera as most of the inhabitants of western Europe, the United States, and even Hong Kong and certain other parts of the Far East. The large numbers of photographs exhibited in the various exhibitions showed a range of technique and imagination from many countries of almost uniformly high standard even if a little overwhelming in quantity.

An interesting piece of equipment was the Meteor negative viewer, in which a negative could be viewed as a positive. There is a physical phenomenon called "Extinction of Fluorescence", which was described by Goethe in his "Farbenlehre" (published 1810) and has been a basis for experiments to reverse a negative. If a fluorescent layer is excited by ultra-violet light, and at the same time exposed to infra-red light the layer remains dark; that is, the infra-red light causes an extinction of fluorescence. If a negative is placed into the infra-red radiation and so projected on the continuously excited screen by a system of lenses, the fluorescence of the screen is reduced in accordance with the light values of the negative. In other words, the clear parts of the negative produce darkness on the screen and vice versa. The Meteor process works continuously; the positive image on the screen remains as long as the exciting ultra-violet and the extincting infra-red radiations are switched on. The manufacturers are Meteor Apparatebau, Paul Schmeck GMBH, Siegen/Westf., Germany.

A new cinema projection system, "Todd-a-o superwide screen", had its first showing in Europe and was startling in its appearance of reality—particularly during the showing of a motor-cycle race filmed from a motor-cycle. All the audience visibly leaned to right or left as the corners were turned with screaming tyres!

Solar Still at Mildura

An experimental solar still for the demineralisation of water from artesian wells was operated by the Beaurepaire Tyre Service at Mildura, Victoria, in Australia, from January to April of last year. Based on earlier investigations of the Commonwealth Scientific and Industrial Research Organisation, the still had a total area of 48 sq. ft. and produced up to eight imperial gallons per day. The apparatus consisted of a glass collector surface set over a shallow trough of black plastic, into which water was siphoned and evaporated by the heat of the sun. The vapour then condensed and drained into storage-tanks. This water was used mainly for car batteries within the area.

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